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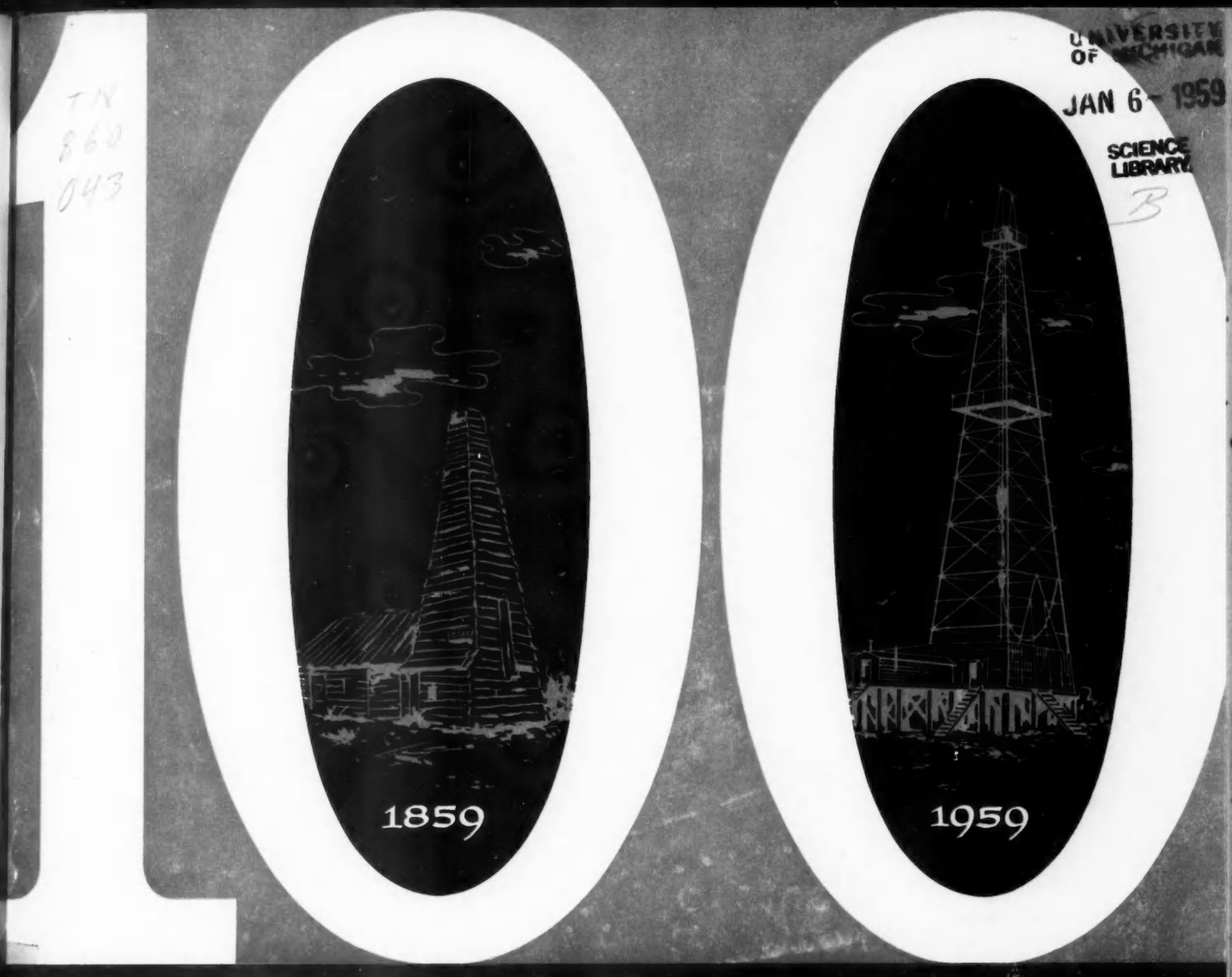

WORLD OIL

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OIL'S 100th Anniversary 1859-1959

JANUARY 1959

A Century of Oil

In its 100 years, oil has led the world into its greatest era of industrialization. A major factor in this achievement has been the oil industry's ability to provide low cost, highly efficient products in abundance.

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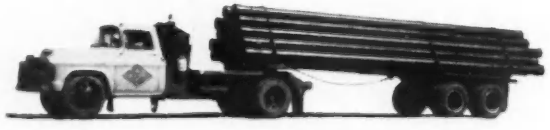

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Dear Reader:

If you've noticed a distinct improvement in WORLD OIL in recent months, here's why: Changes have been made that are designed to make the magazine easier for you to read and to use.

Some examples:

Beginning with this Centennial Issue, the front cover has a "new look." The advertisement has been removed. Henceforth, the front cover will be utilized to call your attention to some of the more important editorial articles.

A rearrangement of the technical-operating articles has been effected to help the busy reader. Hereafter, technical-operating articles will be grouped in a single editorial section. Subject matter will be arranged so it will be easier for the majority of readers to clip and file articles.

Our popular Operating Hints and informative monthly statistical material now are positioned near the front of the book for your convenience.

An easier-to-read typeface for article titles . . . larger page numbers . . . and other refinements.

Other changes are being planned. Watch for them in coming issues.

One thing about WORLD OIL has not been changed. That's our policy of providing you with top-notch technical operating articles and informative economic and management articles. Articles that will help you do your job better and cheaper.

Plans are shaping up for 13 more outstanding issues during the coming year. You'll find more about some of these plans on pages 5 and 6.

William Dudley

Publisher

WORLD OIL published every month except semi-monthly in February and August. Second class postage paid at Houston, Texas

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WORLD OIL

SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

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VOLUME 148, NO. 1 JANUARY, 1959

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For a 'Quick Look' at this issue, turn the page . . .

a *Quick Look* at WORLD OIL this month

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first

A Century of Oil . . .

THE OIL INDUSTRY'S 7 billion barrel-a-year crude production level is twice the output of 10 years ago and 12 times that of 40 years ago. This remarkable achievement, required to fulfill demand, has been made possible only through continuing and far-reaching advances in the industry's technological phases.

Development of better techniques, equipment and services is the primary reason for the ever-expanding ability to find, develop and produce crude oil and gas at reasonable cost. In an effort to trace the importance of this progress as a tribute to the oil industry on completion of its first 100 years, WORLD OIL's staff has spent several months researching and writing the 81-page technical history which begins on Page 133. This special presentation is furnished as a valuable reference source with lasting value for WORLD OIL readers whose very lives are centered around the oil industry.

Following is a brief review of the important source material available in WORLD OIL's Century of Oil:

I. The Emergence of Order Out of Chaos

Major non-technical factors affecting oil industry progress, including growth of competition, conservation, prices, taxes, state and federal regulations, annual demand, overseas expansion and exports. Starting on **Page 135.**

II. Oil Discovery Techniques

A complete historical report on the development of exploration equipment and techniques, including non-geologic prospecting, surface geology, subsurface geology, well samples and logs, geophysics, aerial photography, history of reserves. Starting on **Page 148.**

III. Drilling Practices

Drilling methods, derricks, rotary tables, transmission systems, prime movers, blowout preventers, bits, hoisting systems, are just a few of the subjects that are traced from their inception to modern day use in this well-illustrated history of drilling's technological growth. Starting on **Page 159.**

IV. Detecting Presence of Oil in Hole

Man's progress in improving his ability to detect oil and gas is discussed—from the inefficient early days of "guesswork" detection to the development of core and mud analysis, coring, core bits, drill stem testing, and logging. Starting on **Page 181.**

V. Completion Methods

What was the earliest well completion method? What equipment was used? How did the early methods and equipment evolve into the highly efficient operations of today? These questions are answered in detail in the history of completion methods, casing, water strings, screen liners, perforators, tubing, welding, cementing, plus many other completion subjects that are presented, starting on **Page 185.**

VI. Production Operations

A complete review of developments that have made it possible to recover oil in greater quantities at lower cost, including the history of wellhead control, well stimulation, oil and gas separation, treating, automatic controls, and secondary recovery. Starting on **Page 191.**

Plus these additional technical operating features . . .

☐ **Here's an easy-to-understand nomograph** for calculating recoverable gas reserves. The method yields reasonably accurate results if basic reservoir data are known. Field personnel need not have a thorough knowledge of reservoir engineering to understand this article. . . . . **Page 215**

☐ **High-speed diesel engines** require proper fuel oils for efficient operating results. The operational life of the component parts depends largely on the distillation, refining and non-corrosive properties of the fuel oil. . . . . **Page 218**

☐ **A method for determining the percentage of production decline** and the time element involved in each case by the application of the semilogarithmic decline curve is explained in the article "Expedite Reserve Estimates with Semilogarithmic Decline Curves" . . . . . **Page 220**

☐ **Shallow hole air drilling** proves successful in water-flood operations . . . Air drilling need not be confined to medium or deep drilling. Faced with the problem of quickly extending a water-flood project in the Hogshooter field of Oklahoma, The Carter Oil Company contracted for 18 production

and water injection wells to be drilled by air. The shallow air drilling operation proved successful. For a description of this operation, turn to. . **Page 224**

☐ **Ancient beaches provide clues in search for oil** . . . A study of the petroliferous Permian Lyons sandstone in the Denver Basin of Colorado indicates that it accumulated as an ancient beach. Since shore processes localize areas of clean sand with good permeability, recognition of ancient beaches can become a device for localizing oil accumulation. For a complete discussion, turn to **Page 227**

☐ **Offshore corrosion costs cut by "cold galvanizing"** . . . While cathodic protection has proved its worth for immersed structures, the real problem is in the splash zone and in the atmospheric zone. An inorganic silicate and metallic zinc coating that can be chemically cured has been applied to these areas with good results. . . **Page 234**

From Trinidad to Tulsa

☐ **The career of A. Beeby-Thompson,** internationally known pioneer geologist, is the chronicle of the obstacles which early-day geologists had to meet and overcome to play their leading roles in the development of the oil industry. Beeby-Thompson's own account of these hardships appears in his story of Trinidad in the early days. **Page 247**

☐ **IPE at Tulsa to feature oil industry progress** . . . Plans are rapidly taking shape for the biggest International Petroleum Exposition in the 36-year history of the event. To be held in Tulsa, May 14-23, the show is expected to attract more than 30,000 visitors from the U.S. and 51 countries. Exhibits worth one-half billion dollars will be displayed by more than 2,000 oil companies **Page 254**

Ideas make editorial quality

THREE DAYS of informal editorial sessions was the schedule for eight WORLD OIL industry guests* and 11 staff members attending the annual Gulf Publishing Company editorial conference, held this year at Fort Clark (Bracketville, Texas), December 2-4. Five meetings were held to evaluate present editorial content and to develop article ideas for the 14 issues WORLD OIL will publish in 1959.

Guests, shown seated at the table, included (from left to right): Barrett Booth, manager of operations, The Atlantic Refining Company, Lafayette, La.; Arthur Buzzini, Buzzini Drilling Company, San Antonio; Harold S. Kelly, chief production engineer, Phillips Petroleum Company, Bartlesville; Charles Miller, general production manager, Kerr-McGee Oil Industries, Oklahoma City; Edward Bland, Bland and Barnhardt Drilling Company, Casper, Wyo.; Robert L. Walker, production superintendent, East Texas Division, Shell Oil Company, Kilgore, Texas; Walter Buzzini, Buzzini Drilling Company; J. H. Marsee, chief engineer, Loffland Brothers, Tulsa.

Staff members, from left to right: Don Lambert, associate editor; Robert M. de Sombre, vice president, assistant general manager; Gilbert M. Wilson, West Coast district editor; Jack F. Earl, engineering editor; Robert Scott, engineering editor; Don Kliewer, editor; Warren L. Baker, vice president, editorial director; Wallace Fitzgerald, managing editor; L. J. Logan, associate editor, international; Harrison T. Brundage, East Coast district editor, and Anthony Gibbon, Mid-Continent district editor.

Shortly after the above picture was taken, WORLD OIL guests and editorial staff spread out over Fort Clark's 10,000 acres to hunt deer.

* Attendance by oil men at WORLD OIL editorial conferences does not necessarily constitute an endorsement of WORLD OIL by the companies for which they work. But it is an indication of the cooperation existing between the industry and its press.

Turn the page for a look at what's ahead in World Oil . . .

Forecast in February

WHAT DOES the New Year hold for business, your industry, you?

Reasonable and dependable forecasts are highly desirable and helpful. Because they are so essential, WORLD OIL each year spends considerable time and effort preparing and publishing annual forecasts of trends and developments lying ahead for the petroleum industry.

The next such forecasts will appear in the annual Forecast-Review Issue of February 15, 1959.

The forecasts in that issue will be exceptionally significant. For more than a year the industry has been going through a difficult period.

The general business recession directly and promptly exerted an adverse effect on oil companies and their suppliers. Demand for petroleum products quit growing and, in some instances, decreased. Sales decreased and prices weakened. Oil company earnings decreased. Drilling and other forms of spending were reduced.

Lately, there has been an apparent reversal of downward trends in the industry. Demand for oil has been improving. Better business has been promised for the future.

However, at this turning point, there still are many uncertainties in the outlook. There are many questions yet to be answered.

You will have the answers to these important questions when you open the pages of WORLD OIL's annual Forecast-Review Issue of Feb. 15, 1959.

Order Your Index Now

ANOTHER YEAR and another annual WORLD OIL Editorial Index is already in the hands of the printer. This convenient index, an annual service to WORLD OIL readers, will cover all issues published during 1958 and be bound in convenient pamphlet form. It will be sent FREE to all subscribers requesting copies.

All articles which appeared during 1958 are indexed by author and by subject matter for quick reference. Hundreds of our readers requested copies of the 1957 index. We have tried to estimate the demand this year, but to be certain of your copy, send in your request early. The supply will be limited.

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PETROLEUM REFINER and THE REFINERY CATALOG for the oil, gas and petrochemical processing industry.

PIPE LINE INDUSTRY and THE PIPE LINE COMPOSITE CATALOG for the oil and gas pipe line industry.

Indexed by Industrial Arts Index and Engineering Index

Determined Men Built the Oil Industry

Founder of Sun Oil Company, who proclaimed that *"the way to be successful in America is to give the people better quality and value,"* typifies the special breed who made oil a public servant.

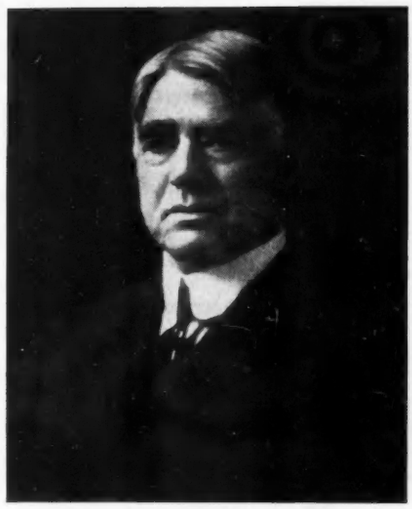
JOSEPH NEWTON PEW was eleven years old when Colonel Edwin L. Drake's "Folly" turned the joke on townspeople who had ridiculed his perseverance in drilling for oil.

The impact of that historic event on young Joe Pew, helping out on his father's farm less than 50 miles away, is unknown. But some 10 years later he caught the "oil fever" that swept Oil Creek Valley.

Opening a real estate office at Titusville in his early twenties, he soon was trading in oil lands and mineral rights. Before his thirties he had gone broke, recouped his losses, paid off his debts, and launched a new enterprise—the commercial use of natural gas.

With E. O. Emerson as a partner, he formed the People's Natural Gas Company in Pittsburgh (the first large U.S. city to enjoy natural gas) and went on to engage in oil exploration, production and pipelining in Ohio and later in Indiana, Illinois and West Virginia. In 1894 the partners became owners and operators of a small refinery at Toledo, Ohio.

One of the things that troubled Mr. Pew most was the high cost of rail transportation for oil. The Lucas gusher at Spindletop in 1901 provided a source of crude oil near deep water. Mr. Pew moved quickly to establish a new refinery on deep water at Marcus Hook, Pa., and to acquire production and storage on the Gulf Coast near Beaumont.



JOSEPH NEWTON PEW

Now the mold was cast for the Sun Company, incorporated in New Jersey in 1901, and subsequently renamed Sun Oil Company. Technological experimentation and financial conservatism were to be characteristic parts of the mold. Others included balanced integration, emphasis on economical transportation, and the location of refineries adjacent to centers of dense population.

An overriding credo was Mr. Pew's stated conviction that "the way to be successful in America is to give the people better quality and value."

The forceful personality and indomitable spirit of Sun Oil's founder stamped an indelible mark on the company, and on his sons, John Howard and Joseph Newton, Jr., who have carried on the business since his death in 1912.

For its size, Sun Oil has contributed substantially to the advancing technology of the oil industry, and thus to the industry's ability to serve people better. It led in demonstrating that high quality lubricants could be made from naphthenic, as well as paraffinic, crude oil; it pioneered the long-distance products pipe line; its subsidiary, Sun Shipbuilding & Dry Dock Company, developed the all-welded tanker.

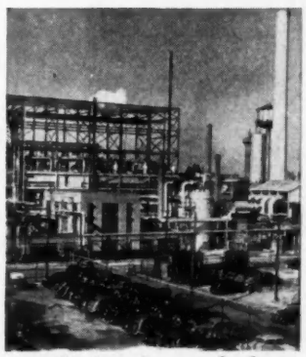
Sun Oil engineering made the Houdry Catalytic Cracking Process a large-scale commercial reality, providing for oil refiners their first chemical approach to the rearrangement of oil molecules. Most recently, Sun Oil took a giant forward step in the technique of motor fuel marketing with its development of the Custom Blending system, giving motorists for the first time an opportunity to fit fuels to the requirements of their individual cars.

These are the more notable among the many accomplishments of Sun Oil in building on the blueprint drawn by Joseph Newton Pew, one of the special breed of determined men who had the freedom to build the oil industry as an instrument of service to the American people • SUN OIL COMPANY, Philadelphia 3, Pa.

Pioneering Achievements of Sun Oil Stem from Founder's Credo

Some said it couldn't be done but Sun made quality lubricants from naphthenic crude.

First long-distance pipe line for movement of products was a pioneering step made by Sun.



Sun Engineering made large-scale catalytic cracking a commercial reality for oil refiners.

Custom blended motor fuels, a radically new concept in marketing, is one of Sun Oil's latest.

For more data on advertised products, use Readers' Service Cards, last page.

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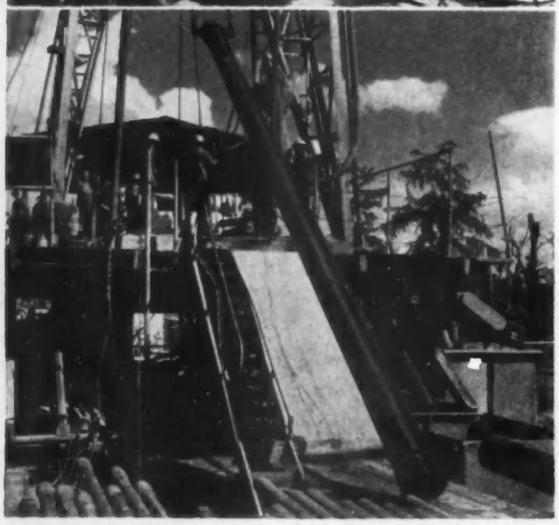

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Looking Ahead

Eight Developments to Watch in '59

1. Demand to increase . . . Aided by severe winter weather, "oil products demand in first half of '59 is expected to increase five percent over '58 first half," Indiana Standard Board Chairman Frank O. Prior predicted recently.

Twelve month forecast: Continental Oil President L. F. McCollum makes the following forecast for the coming year—"Looking forward to 1959, there are reasons for 'guarded optimism' about the industry's prospects. Aided by continuing improvement in general business conditions, domestic petroleum demand is expected to increase 4 to 5 percent, combined with cessation of inventory liquidation and adequate restraints on imports, should permit domestic petroleum production to increase about 7 percent.

"Refinery runs should increase approximately 5 to 6 percent. The increase in demand should also restore product prices to more satisfactory levels, providing the industry continues to exercise common sense with regard to inventory management.

"The most important problem facing the industry in 1959, and the years beyond, is that of halting the persistent rise in oil finding and development costs."

Long range forecast: Chase Manhatten Bank predicts that in 1957-67 period, Free World oil operators will spend $140 billion to drill 670,000 wells and 3 billion feet of hole. Capital expenditure prediction is nearly double $72 billion spent in previous ten years. This highly promising forecast is based on expected Free World demand increase from 16 million barrels daily in '57 to 29.5 million in '67. U.S. demand alone is expected to increase from 8.8 million barrels daily in '57 to 14.4 million in '67.

2. Capital expenditures . . . U.S. Government survey reveals oil industry will start '59 spending slightly less than last quarter of '58. After hitting recession bottom in third quarter with capital expenditures at seasonally-adjusted annual rate of $2.17 billion, oil industry increased total to $2.30 billion in fourth quarter. First quarter '59 rate is expected to be $2.28 billion.

3. Equipment and methods . . . Look for stepped up efforts to develop new equipment for deeper exploratory drilling. One industry spokesman reports that most minimum casing and tubing tolerances were established 20 years ago. Therefore, improvements in manufacturing processes might now permit minimums to be raised slightly. This would improve casing and tubing at little extra cost.

Improved oil recovery methods also will receive much attention in '59. Socony Mobil's T. W. Nelson recently told Interstate Oil Compact Commission that a reported 270 billion barrels of crude have been discovered in the United States. About 57.6

billion barrels of the total have already been produced and 30.3 billion barrels are listed as economically recoverable with present methods. That leaves 180 billion barrels of crude discovered, but not presently recoverable.

Two promising methods—gas and water injection and in situ combustion will undergo extensive tests during '59.

4. Drilling outlook to improve . . . Rig activity during '59 will exceed '58 levels (See Page 28 . . . **Recession-created cut in total operable rigs** is expected to improve outlook for contractors—**U.S. contractors** will continue to put more men and equipment into overseas operations . . . **Air-gas drilling** will be used more extensively.

5. Regulation and the courts . . . Antitrust investigations will continue to plague the industry—**Memphis Decision reversal** will increase supply of natural gas to consumers, revive shelved pipe line construction projects—**Attitude of Supreme Court in Memphis Decision** may enhance chances of new natural gas bill in next session of Congress—**Senator Proxmire (Wisconsin) says** he will put his depletion bill in the hopper again, and believes he can succeed in cuting provision from 27.5 percent to 21 percent for $1.5 million gross income operators and 15 percent for operators with $5 million-plus gross income. Depletion provision will have one of its stiffest tests in '59.

6. Imports and spacing . . . With adoption of mandatory import controls a strong possibility, independent operators are expected to concentrate '59 efforts in support of unified industry move to obtain wider well spacing. An increasing number of oil men see greater allowables resulting from fewer drilled wells as the "salvation of the independent."

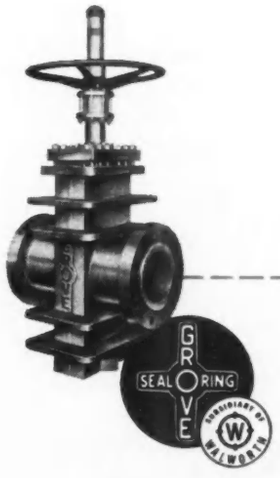
7. More activity in Alaska . . . The 49th state-to-be will continue to be one of the hottet exploration areas in North America. Of Alaska's more than 100 million acres of oil and gas possibilities, about 40 million are now under lease. This year may well mark the beginning of Alaskan competition with Canada to supply crude to refineries in the U.S. Northwest.

8. Shale oil and atoms . . . Efforts will continue to find a way to make shale oil competitive with crude. Twenty oil company officials have been invited to attend Atomic Energy Commission meeting in Dallas January 6-7 to discuss possibility of releasing shale oil using underground atomic explosions.

Atomic Energy Commission experts say 600 million barrels of crude could possibly be freed from Athabasca tar sands with a 1,000 kiloton A-bomb. They claim costs for such a project should be unusually low. Nuclear scientist Dr. Edward Teller also sees possibility of using atomic energy to recover crude from depths far below the limits of present drilling methods and equipment.

Embryonic oil field in eastern Venezuela? . . . Creole Petroleum Corporation and Standard Oil Company (New Jersey) report studies of a shallow (115 feet) stratigraphic trap in the Orinoco delta where crude petroleum is actually accumulating in geologically recent sediments. Beds are said to be not much older than Egypt's pyramids.

.....wipe out the need for lubrication



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Good Wells Make Good News

A Monthly Report On Wells That Are Now Worth More

January, 1959

Chances for increasing your net income or making your wells worth more can often be enhanced by a Dowell acidizing treatment. Here are four recent Dowell acid treatments that helped producers increase income:

- **San Juan County, Utah** (New Oil Well) This well was completed through perforations from 5370 to 5490 feet into the Aneth lime. Before treatment, well swabbed 10 boph. Dowell washed perforations with Mud Acid and then acidized in five stages using Fixafrac® (temporary plugging service) between stages. 6500 gallons Dowell acid with emulsion-preventing and surface tension reducing agents were used. After clean-up, well tested 1050 bopd with 2000 psi surface pressure.

- **Garvin County, Oklahoma** (New Oil Well) This well was completed in the Hunton lime of the North Lindsay pool. Perforations were from 10,198 to 10,240 feet. Dowell acidized with 10,000 gallons Retarded Acid. Injection was down tubing at 6 bpm and 4000 psi. Before treatment, well swabbed 20 bopd. After clean-up, it flowed 118 bopd.

- **Barton County, Kansas** (Old Oil Well) This well was initially completed open hole in the Arbuckle dolomite from 3332 to 3339 feet. Initial production was 66 bopd after a 500-gallon acid treatment. After five years, production had declined to 8 bopd and 12 bwpd. A 200-gallon regular acid job was unsuccessful. Dowell engineers recommended treating with 1250 gallons regular acid followed by 100 pounds of magnesium pellets and 1000 gallons Stabilized Acid. This treatment had a three-fold purpose. It was designed to speed reaction with the dolomite, and melt hard hydrocarbons with heat; the stabilizing agent was added to keep dissolved iron salts from re-precipitating and plugging the formation. After settling down, well pumped 54 bopd and 240 bwpd. Treatment costs paid out in less than 20 days.

- **Southwestern Alberta, Canada** (New Gas Well) Pay was a 900-foot section of the Mississippian dolomitic lime at about 12,000 feet. Initial production was low, but thick pay made extensive treatment advisable. Operator decided on series of acid jobs, cleaning out and running back-pressure tests after each treatment to evaluate "skin effect." The object was to minimize pressure loss near bore hole so maximum potential might be reached. Dowell performed five treatments, using 60,000 gallons acid with surface tension and demulsifying agents, plus 20,000 gallons Retarded Acid. Calculated open flow was over 65 million cubic feet per day after treatments.

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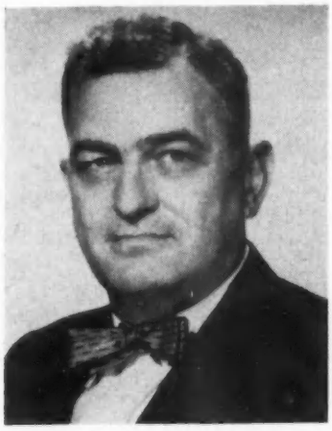


Better tools increase supply of oil

By J. U. Teague, Past President
American Association of Oilwell Drilling Contractors

World consumption of petroleum has reached nearly 7 billion barrels annually as the industry begins its second 100 years. This is 12 times greater than 40 years ago, and twice as much as a scant decade ago.

The ability to furnish an abundant supply in the face of this tremendous increase in consumption has been possible only because of outstanding advancements in methods and equipment. Today's huge consumption needs could not be supplied if we still were dependent upon the equipment and methods of 25 or 30 years ago.

The ability to find, develop, produce, and refine larger and larger quantities of oil and gas at reasonable costs has been expanded many times by great technological progress.

Advances in drilling, for example, make it possible to reach oil at greater depths. The first 10,000-foot test was not completed until 72 years after Colonel Drake drilled the world's first oil well to a depth of 69½ feet. Drilling depths have advanced to 25,000 feet in the last 28 years, and 10,000 to 15,000-foot wells are common every day occurrences.

Greater penetration depths have made huge additional quantities of oil available. Much of the world's production today comes from depths below 10,000 feet, and an appreciable quantity from 15,000 feet.

In addition, far-reaching advancements have overcome conditions which once caused hole abandonment. We now can overcome caving horizons, heaving shales, high pressures, cavities, heavy water flows, exceedingly hard zones, lost tools, and many other obstacles and difficult conditions. These advances permit reaching of oil lying below such troublesome formations.

Equally impressive progress in discovery, producing and refining techniques also have contributed to the enlargement of the world's supply of oil.

Much of the credit for the industry's technological advances is due to the research and development work of numerous equipment manufacturing, supply and service companies. Many tools and services highly important in today's operations have been the brain child of an individual, equipment manufacturer or service company.

Many oil manufacturers and service concerns constantly conduct extensive research programs directed toward improved performance or new methods. Such research activity is responsible for much of the industry's technological progress. More than 9,000 engineers are employed by oil field equipment manufacturing, supply and service organizations. They labor in the laboratory and in the field, developing new and better techniques and tools.

For example, the work of manufacturers and service companies to a very large degree is responsible for most of the advancements in bits, cementing operations, tool joints, metallurgy, logging, perforating, fishing, mud pumps, blowout prevention, etc.

Seldom do we in the oil business stop to consider that oil field operations are unique. Since they are conducted far below the earth's surface in extremely restricted space, it has been necessary to design and develop special tools and techniques totally different from those used by other industries. Nevertheless, the initiative, ingenuity and inventive skill of man has been of such high quality as to overcome these difficulties.

The great technological progress of the industry is the direct result of a healthy, highly competitive business operating under the free-opportunity American economic system. Only the hope of adequate

EDITORIAL (continued)

financial reward will move individuals or companies to the creative and productive heights which are characteristic of the U.S. oil industry.

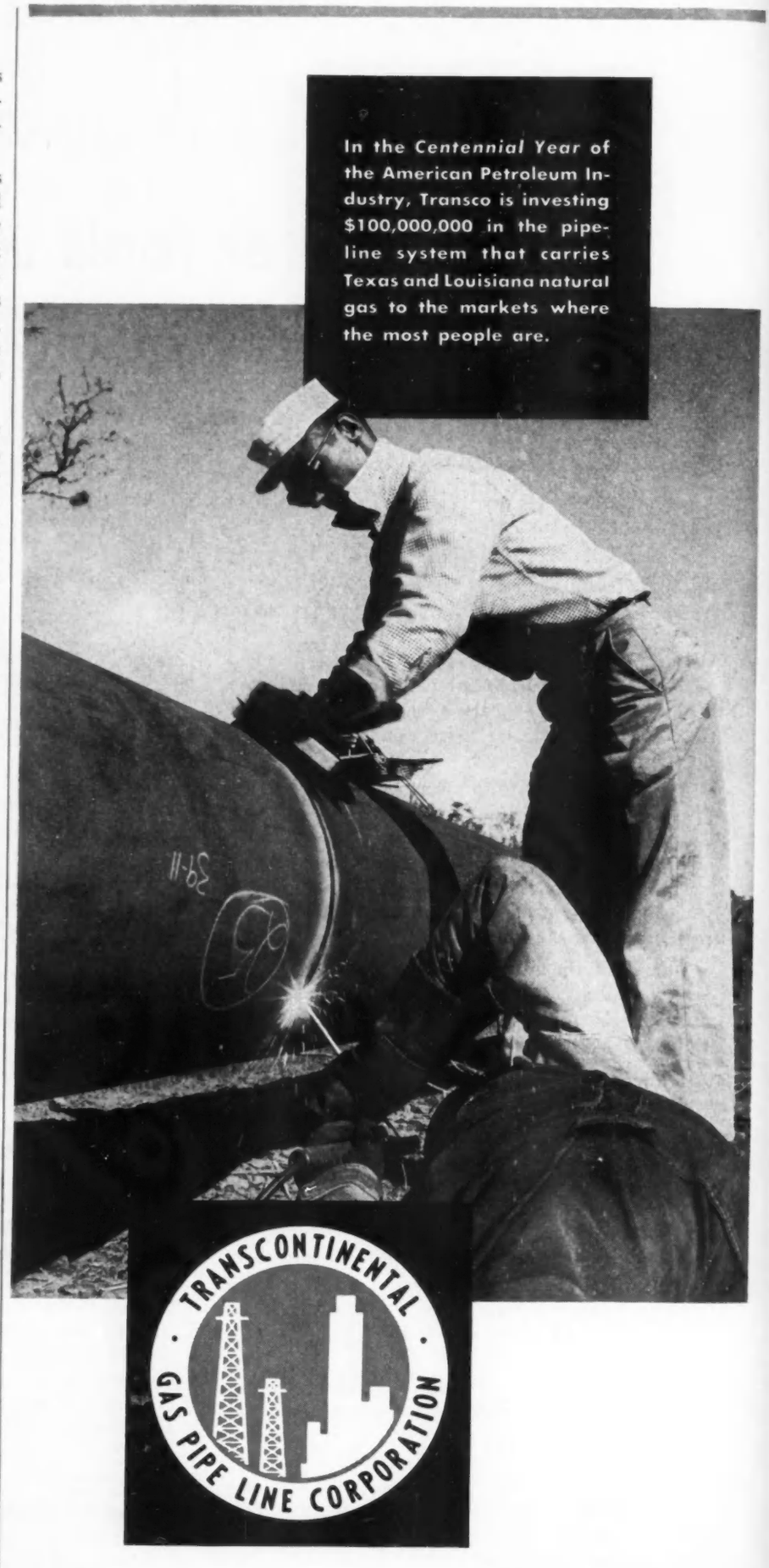
As long as the United States shuns the adoption of measures which would regiment or retard research, destroy the incentives of invention, or prevent the free play of competition and opportunity, new and improved tools and services will be forthcoming. They will continue to play a vital role in making available sufficient oil to supply huge future needs.

There can be no doubt but that the most essential of all national policies is the maintenance of an open door to financial opportunity, where energetic men who take risks can hope for rewards. The doors to opportunity must never be permitted to close. As long as there is opportunity to gain financial rewards, man's initiative, ingenuity, energy and courage can be depended upon to continue to provide new and better tools and techniques. But, once the door to individual opportunity is closed, stagnation is certain.

It is fitting, as we look back on 100 years of oil progress at this time, that contractors and operators should give recognition to the important role manufacturers, suppliers and service companies have rendered in developing new and better tools and techniques through their research efforts.

Far too many of us in the operating phases of the industry are prone to think of these companies only in terms of their manufacturing plants, warehousing facilities, delivery services or even financial assistance. These are vital functions which have contributed much to the industry's progress and development. However, they are only a part of the contributions of the industry's equipment manufacturing and service branch.

At the same time, it is essential that we not fail to appreciate the absolute necessity of maintaining worthwhile financial returns for risk capital and individual enterprise. If opportunities to gain individual rewards are kept open, further advancements in equipment and technological knowledge will make it possible to provide a sufficient supply of oil to satisfy an incredible additional growth in consumption during coming years.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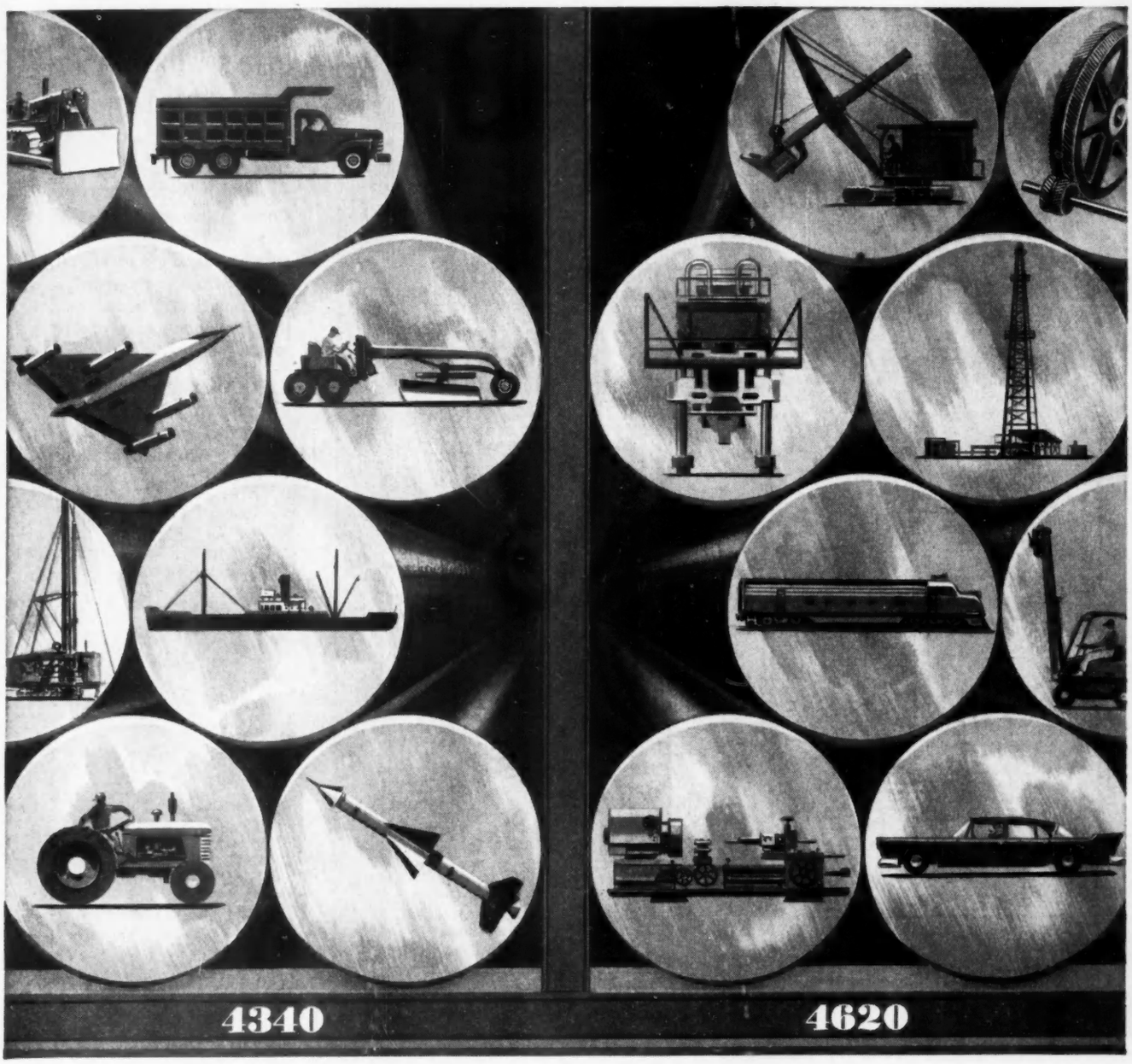

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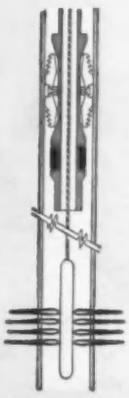
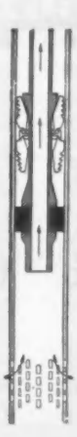


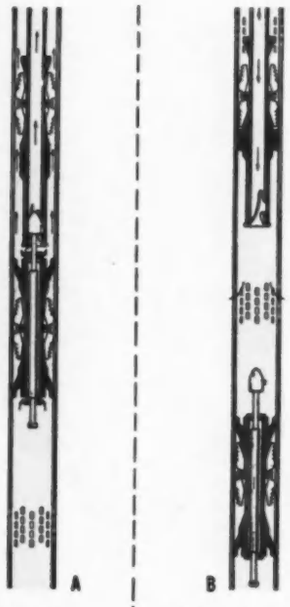
PERFORATE

FRACTURE ACIDIZE CEMENT

SWAB AND TEST

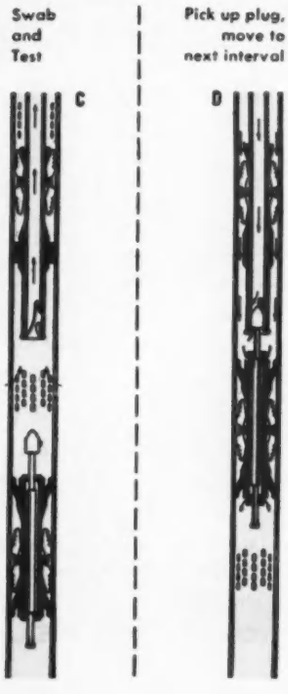


or use it with a **BAKER RETRIEVABLE BRIDGE PLUG** for as many straddle operations as required... in **ONE ROUND TRIP!**



A — Run tools in together

B — Release Plug, straddle interval, fracture or acidize



C — Swab and Test

D — Pick up plug, move to next interval

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Warren L. Baker, Editorial Director

U. S. oil outlook greatly improved

Rising demand and reduced stocks presage higher U.S. producing rates. Increase would be sizable if imports are curtailed.

The U.S. oil outlook has undergone great improvement in recent months. The industry begins 1959 in its best statistical position in several years.

Excessive stocks have been eliminated by drastic curtailment of supply during much of 1958. Demand is improving, particularly in recent weeks.

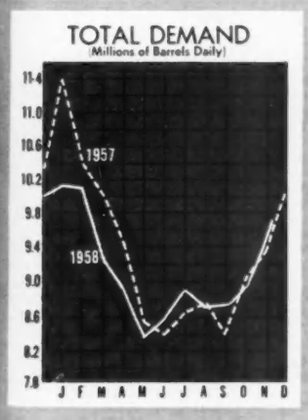
These conditions presage the need for increased U.S. producing rates in 1959. However, because of the uncertainty of future import volumes, particularly of refined products, it is difficult to estimate probable future U.S. production volumes at this time. Aside from rising costs, the question of importing rates is the one discouraging element on the horizon at this moment.

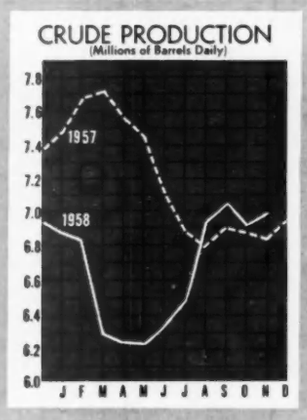
Outstanding progress has been made in reducing stocks during recent months. Inventories of both crude oil and major refined products now are below year-ago levels by substantial margins, whereas earlier in 1958 they had been above the preceding year by considerable margins.

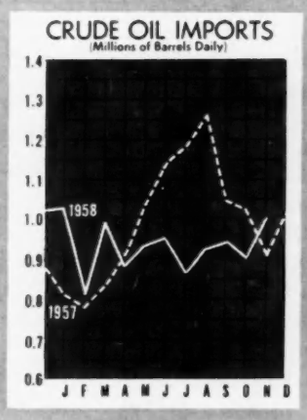
U.S. gasoline inventories totaled 174.7 million barrels in mid-December, 14.1 million less than a year ago and even 2.3 million barrels below two years ago. Four months ago these stocks had been 4 million barrels greater than in the preceding year. Gasoline inventories outside of California currently are nearly 10 million barrels below a year ago, and 3 million less than two years ago.

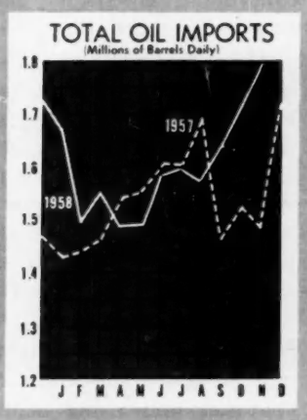
Distillate fuel oil stocks also have improved greatly. Colder than normal weather over a large portion of the nation has caused particularly sharp reductions in recent weeks. Distillate

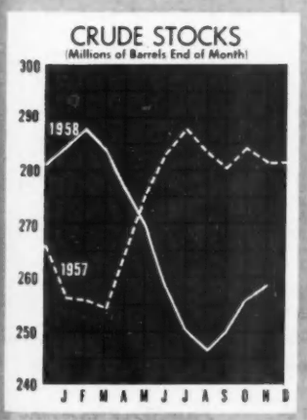
Petroleum Trends...

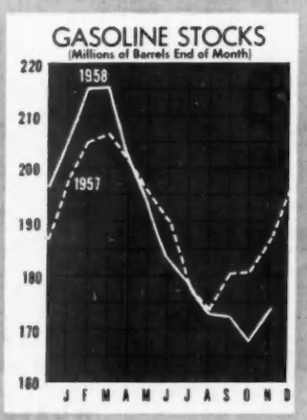


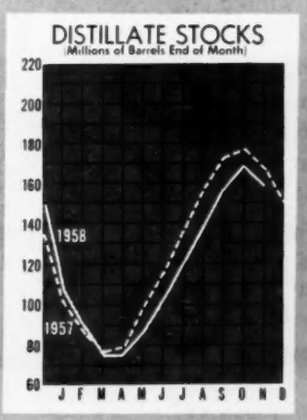


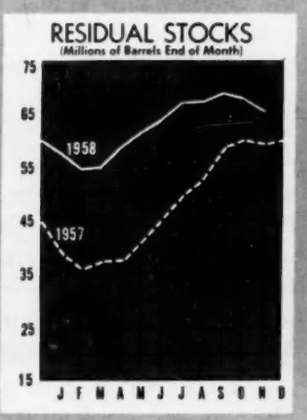












inventories in mid-December totaled 159.3 million barrels, 11.2 million barrels less than a year ago in contrast with being only 7.6 million below the previous year only a month ago. All the reduction in distillate stocks has occurred outside of California. Distillate stocks are still somewhat high, being 20 million barrels above two years ago, but continued cold weather would go a long ways toward further improving their position.

Residual fuel oil stocks on a national basis are 3.8 million barrels greater than a year ago. However, outside of California they are 3.0 million barrels below last year's volumes.

Crude oil inventories in mid-December were 22.7 million barrels less than a year ago, and 16.6 million barrels below levels of two years ago. All the decrease has been outside of California. Crude oil stocks outside California now are 25.0 million barrels less than both a year ago and two years ago.

A sizable increase in consuming rates has been a big factor in improving the industry's economic position during recent months. Consumption has risen sharply because of recent colder than normal weather over much of the nation and continuing improvement in general business conditions. The latter enhances the outlook for higher oil demand in 1959.

Most forecasts of U.S. domestic petroleum demand now look for 1959 levels to be 4 to 5 percent greater than in 1958. This means demand in 1959 is expected to average 375,000 to 450,000 barrels per day more than in 1958. If cold weather continues in the northern sector, it is likely to average nearer the larger figure.

More satisfactory prices for products should result from reduced inventories and rising demand, unless the industry fails to hold new supply in line with current needs. This would be a highly significant development.

Improved refinery profit margins would alleviate much of the downward pressure that has been quite pronounced during the last year. Better crude prices to offset continuing advances in costs are not likely, but there is a good chance that crude oil markets would be firm at present levels if product prices improve.

U. S. Monthly Oil Trends

(THOUSANDS OF BARRELS DAILY)

	NOVEMBER			Oct.	JANUARY-NOVEMBER		
	1958	1957	% Diff.	1958	1958	1957	% Diff.
U.S. Crude Oil Production	6,990	6,824	+17.1	6,910	6,664	7,197	— 7.4
U.S. Nat. Gas Liquids Prod.	810	832	— 2.7	800	787	805	— 2.2
U.S. Total Imports	1,809	1,488	+21.6	1,720	1,657	1,528	+ 8.4
East Coast Crude Imports	806	632	+27.5	709	762	735	+ 3.7
Total Crude Imports	1,000	902	+10.9	906	942	995	— 5.3
Total Refined Products	809	586	+38.1	815	714	533	+33.9
Total New Supply	9,609	9,144	+ 5.1	9,430	9,107	9,531	— 4.5
Stock Changes All Oils (Daily)	—117	—183	.....	+452	—39	+232	.....
Total Demand All U.S. Oils	9,726	9,327	+ 4.3	8,978	9,146	9,299	— 1.7
Gasoline Demand	3,844	3,702	+ 3.8	4,017	3,959	3,943	+ 0.4
Distillate Fuel Demand	2,098	2,080	+ 0.9	1,489	1,720	1,758	— 2.2
Residual Fuel Demand	1,493	1,573	— 5.1	1,409	1,460	1,572	— 7.1
Domestic Demand, All Oils	9,416	8,959	+ 5.1	8,678	8,863	8,713	+ 1.7
Export Demand, All Oils	310	368	—15.8	300	282	586	—51.9
Crude Runs U.S. Refineries	7,768	7,692	+ 1.0	7,696	7,572	7,929	— 4.5
Domestic Crude Runs	6,785	6,658	+ 1.9	6,764	6,638	6,942	— 4.4
Foreign Crude Runs	983	1,035	— 5.0	932	934	987	— 5.4

	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	November			Oct.	November			Oct.
	1958	1957	% Diff.	1958	1958	1957	% Diff.	1958
Crude Oil	258.1	281.8	— 8.4	255.7	220.7	242.0	— 8.8	222.3
Gasoline	173.9	187.1	— 7.1	168.6	150.6	159.8	— 5.8	146.2
Distillate Fuel Oil	159.0	166.8	— 4.7	166.3	145.4	149.8	— 2.9	151.8
Residual Fuel Oil	65.7	59.6	+10.2	68.2	32.4	28.2	+14.9	33.8
Kerosine	31.5	32.7	— 3.7	32.4	31.2	32.3	— 3.4	32.0

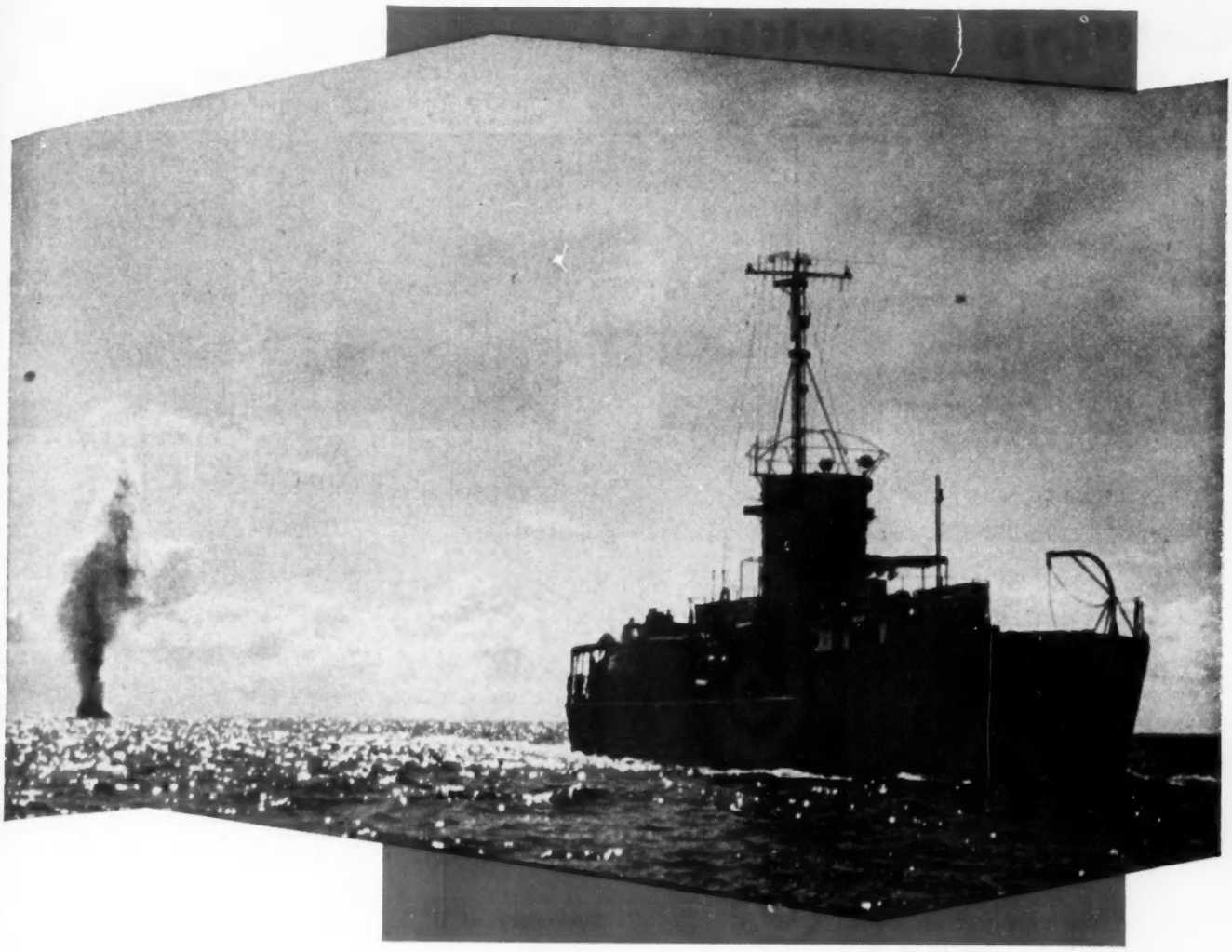
Source: Except for latest two months, all data from U.S. Bureau of Mines. Data for last two months from American Petroleum Institute weekly reports and U.S. Bureau of Mines weekly crude stock report; except U.S. Natural Gas Liquids Production and Demand figures which are from WORLD OIL.

U. S. Crude Production By States

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION November 1958	November 1957	% Diff.	October 1958	TOTAL PRODUCTION January-November 1958	January-November 1957	% Diff.
Alabama	16.4	15.2	+ 7.9	16.3	5,360	4,876	+ 9.9
Arkansas	79.9	84.3	— 5.2	77.1	26,242	28,037	— 6.4
California	854.9	929.8	— 8.1	851.7	287,986	310,912	— 7.4
Colorado	129.5	142.9	— 9.4	132.1	44,471	50,453	— 11.9
Florida	1.2	1.3	— 7.7	1.2	412	422	— 2.4
Illinois	223.9	230.8	— 3.0	224.4	75,061	70,887	+ 5.9
Indiana	31.9	33.8	— 5.6	32.9	10,669	11,780	— 9.4
Kansas	331.6	326.7	+ 1.5	335.9	107,952	111,080	— 2.8
Kentucky	47.5	44.1	+ 7.7	41.8	14,930	15,462	— 3.5
Louisiana	918.9	799.5	+ 14.9	898.2	283,131	297,265	— 4.8
North Louisiana	113.8	109.3	+ 4.1	112.5	38,228	42,448	— 10.0
South Louisiana	805.1	690.2	+ 16.6	785.7	244,903	254,817	— 3.9
Michigan	24.8	26.1	— 5.0	25.6	8,469	9,360	— 9.5
Mississippi	120.4	95.5	+ 26.1	109.8	34,762	36,256	— 4.1
Missouri-Tennessee-South Dakota	0.3	0.5	— 40.0	0.4	116	100	+ 16.0
Montana	77.6	76.1	+ 2.0	77.1	25,761	24,809	+ 3.8
Nebraska	59.3	59.2	+ 0.2	58.0	18,599	17,754	+ 4.7
Nevada-Washington	0.1	0.1	.....	0.1	39	23	+ 69.6
New Mexico	279.5	266.2	+ 5.0	283.7	90,071	86,528	+ 4.1
Southeast New Mexico	252.0	256.4	— 1.7	255.4	82,826	84,318	— 1.8
Northwest New Mexico	27.5	9.8	+180.6	28.3	7,245	2,210	+227.8
New York	5.2	6.9	— 24.6	5.2	1,720	2,461	— 30.1
North Dakota	33.9	35.5	— 4.5	15.1	12,344	12,427	— 0.7
Ohio	16.0	16.1	— 0.6	16.1	5,712	4,597	+ 24.3
Oklahoma	559.0	569.7	— 1.9	555.2	185,197	197,034	— 6.0
Pennsylvania	16.3	20.7	— 21.3	16.8	6,146	7,556	— 18.7
Texas	2,744.4	2,728.2	+ 0.6	2,692.4	852,028	1,000,703	— 14.9
Dist. 1: South Central	47.5	50.5	— 5.9	47.7	15,448	17,909	— 13.8
Dist. 2: Middle Gulf	125.1	128.9	— 2.9	124.3	38,408	48,933	— 21.5
Dist. 3: Upper Gulf	393.6	407.7	— 3.5	375.0	125,006	148,136	— 15.6
Dist. 4: Lower Gulf	203.6	204.5	— 0.5	202.5	58,203	76,257	— 23.7
Dist. 5: East Central	30.4	32.2	— 5.6	31.5	9,998	2,804	+256.6
Dist. 6: Northeast	277.3	277.7	— 0.2	276.6	85,745	108,290	— 20.8
Dist. 7-B: North Central	138.3	143.1	— 3.4	144.3	45,616	52,871	— 13.7
Dist. 7-C: West Central	144.7	154.1	— 6.1	142.6	44,345	53,663	— 17.4
Dist. 8: West	1,072.6	1,011.4	+ 6.1	1,028.8	315,065	369,165	— 14.7
Dist. 9: North	209.3	207.4	+ 0.9	211.5	66,565	69,904	— 4.8
Dist. 10: Panhandle	102.0	103.6	— 1.6	107.5	35,469	35,037	+ 1.2
Utah	77.8	12.3	+532.5	106.1	21,612	3,574	+504.7
Virginia	.....	.....	.....	.....	6	5	+ 20.0
West Virginia	6.1	6.1	.....	6.4	2,023	2,028	— 0.3
Wyoming	333.8	296.4	+ 12.6	330.5	104,901	97,340	+ 7.8

Source: Bureau of Mines and API. Texas districts from API and do not necessarily agree with State totals.



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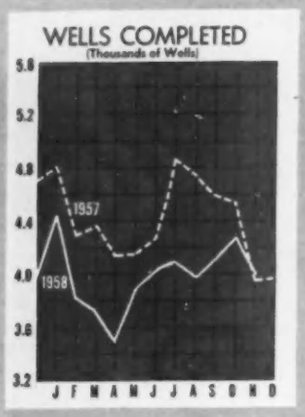
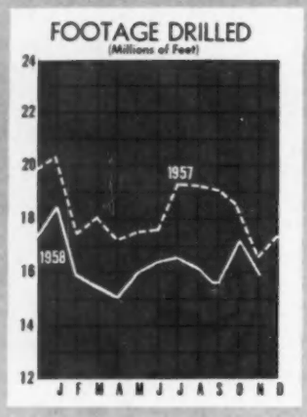
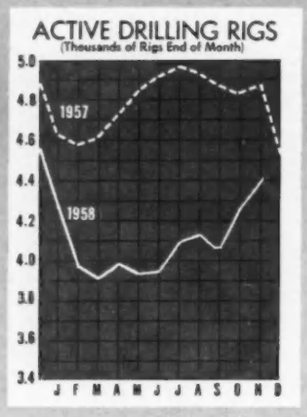
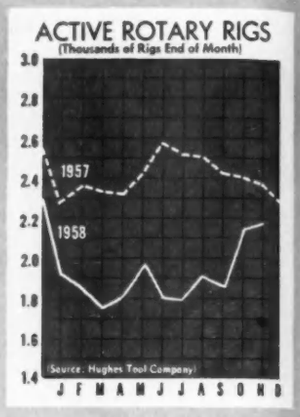
Drilling Activities...









1958 well completions may exceed 48,000

NEW U.S. well completions totaled 44,060 for the first 11 months of 1958, a decline of 4,778 wells, or 9.8 percent, from the same 1957 period. Indications are that total completions for this year will slightly exceed the 48,000-well level.

November's new well completions again exceeded the 4,000-well rate, just as in each of the five previous months. With no major decline anticipated in drilling activity during December, there is every likelihood that total new completions for 1958 will be close to WORLD OIL's mid-year forecast of 47,952 wells.

New completions reported in November amounted to 4,004, or 340 wells less than the 4,344 completions recorded in October and 130 less than the 4,134 completions accounted for in September. Although the November total was lower than in each of the previous two months, this three-month period is considerably higher than the year's low of 3,553 wells in April.

Continued drilling activity at the present rate would mean a total of 48,064 new well completions for 1958, or 112 wells more than the WORLD OIL forecast.

Summary of U. S. Drilling Activity

ITEM	November 1958	October 1958	ELEVEN MONTHS January-November 1958	1957	% Diff.
New Wells Completed:					
Oil	1,960	2,043	21,611	25,262	— 14.5
Distillate	52	56	667	681	— 2.1
Gas	367	374	3,920	3,421	+ 14.6
Service	104	176	1,297	998	+ 30.0
Dry	1,521	1,695	16,565	18,476	— 10.4
Total Wells	**4,004**	**4,344**	**44,060**	**48,838**	**— 9.8**
Footage Drilled (Mln. of Feet)	**15.9**	**17.4**	**178.7**	**201.5**	**— 11.3**

Summary of U. S. Wildcat Drilling

ITEM	November 1958	October 1958	ELEVEN MONTHS January-November 1958	1957	% Diff.
New Field Discoveries:					
Oil	68	69	675	804	— 16.1
Distillate	4	7	80	113	— 29.2
Gas	12	22	204	220	— 7.3
Total Discoveries	**84**	**98**	**959**	**1,137**	**— 15.7**
Dry Wildcats	736	815	7,997	9,316	— 14.2
Total Wildcats	**820**	**913**	**8,956**	**10,453**	**— 14.3**
Percent Productive	10.2	10.7	10.7	10.9	.....
Percent Dry	89.8	89.3	89.3	89.1	.....

U. S. Drilling Activity in November and First Eleven Months, 1958-1957

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR NOVEMBER, 1958 — Oil	Dist.	Gas	Dry	Service Wells	TOTAL NEW WELLS — Nov. 1958	Oct. 1958	Nov. 1957	Total Footage November, 1958	DETAILS FOR JANUARY-NOVEMBER — NEW WELLS 1958	1957	Percent Diff.	FOOTAGE 1958	1957	WILDCAT DRILLING IN NOVEMBER AND FIRST ELEVEN MONTHS, 1958-1957: DETAILS FOR NOV., 1958 — Oil	Dist.	Gas	Dry	Total Wildcats	DETAILS FOR JANUARY-NOVEMBER — Oil	Dist.	Gas	Dry	TOTAL WILDCATS 1958	1957	DRILLING RIGS IN OPERATION (Rigging up, Drilling, Temp. Shut-Down) — Nov. 30, 1958	Oct. 31, 1958	Nov. 30, 1957
Alabama	3			2		5	8	5	43,982	74	88	— 15.9	610,106	726,958				2	2	1			26	27	38	18	15	12
Arkansas	45	1	2	32		80	92	80	257,436	751	1,018	— 26.2	2,508,045	3,087,648	1		1	12	14	7	3	7	127	144	161	43	56	62
California	51		6	40	2	99	98	199	487,904	1,238	2,048	— 39.6	6,030,450	8,804,961	1		1	30	32	8		3	238	249	337	142	125	174
Colorado	10		4	56		70	97	71	357,509	789	745	+ 5.9	4,082,965	3,907,928	3			39	42	26		16	400	442	445	59	61	65
Florida										6	8	— 25.0	55,809	57,082									6	6	8	1	2	2
Georgia										1	5	— 80.0	2,915	25,712									1	1	5			
Illinois	133		8	146		287	199	263	649,490	2,184	2,466	— 11.4	5,009,007	5,657,366			1	62	63	6		1	549	556	705	306	326	260
Indiana	38			59		97	124	72	156,658	807	649	+ 24.3	1,309,565	1,098,248	2			26	28	7		1	212	220	151	112	113	115
Kansas	152		13	164	8	337	381	326	1,164,953	3,415	3,813	— 10.4	11,761,314	13,500,038	10		2	84	96	111		24	762	897	911	327	354	575
Kentucky	48		16	62	3	129	151	162	203,230	1,326	1,643	— 19.3	1,962,508	2,379,304				5	5	10		2	61	73	112	107	107	116
Louisiana	149	23	28	110	1	311	327	290	2,214,711	3,204	3,481	— 8.0	24,705,303	27,446,236	3	1	1	44	49	32	20	7	481	540	584	374	356	399
North Louisiana	69		18	55		142	162	110	503,191	1,268	1,320	— 3.9	4,688,361	4,764,631	2			25	27	15			176	191	177	75	72	81
South Louisiana	80	23	10	55	1	169	165	180	1,711,520	1,936	2,161	— 10.4	20,016,942	22,681,605	1	1	1	19	22	17	20	7	305	349	407	299	284	318
*Gulf of Mexico	22	3	4	4		33	34	49	302,996	451	603	— 25.2	4,327,830	5,748,320				1	1	3	1	2	32	38	66	42	34	74
Michigan	19		1	16		36	47	30	100,274	356	367	— 3.0	1,020,399	1,071,129	1			9	10	7		4	111	122	130	84	77	69
Mississippi	16	1	4	19		40	47	39	320,546	364	360	+ 1.1	3,216,393	2,659,337				11	11	10	1		130	141	178	71	63	47
Missouri							2	1		15	10	+ 50.0	15,612	7,647									8	8	10	3	3	
Montana	10		1	17		28	30	48	122,061	281	392	— 28.3	1,470,852	1,912,920	1			9	10	7	1	5	96	109	152	59	43	49
Nebraska	20			51		71	81	65	417,975	639	818	— 21.9	3,813,927	4,844,165	6			33	39	32			266	298	418	27	37	31
Nevada											5	—100.0		11,260										5			1
New Mexico	87		55	28		170	174	167	725,275	1,829	2,047	— 10.7	8,545,507	9,642,948	2			17	19	34	2	17	207	260	275	162	152	174
Southeast	55		5	20		80	74	94	409,133	912	1,219	— 25.2	4,554,563	6,158,004	2			2	14	24	2	4	137	167	176	73	57	93
Northwest	32		50	8		90	100	73	316,142	917	828	+ 10.7	3,990,944	3,484,944				5	5	10		13	70	93	99	89	95	81
New York	24		1	2	18	45	45	48	53,400	495	471	+ 5.1	587,400	743,600												42	42	68
North Dakota	18			12		30	42	26	174,649	385	263	+ 46.4	2,494,993	1,790,059				5	5	21			94	115	120	28	36	48
Ohio	39		23	26		88	90	101	240,446	906	938	— 3.4	2,346,540	2,252,226				3	3				10	10	9	218	228	222
Oklahoma	264	1	21	181	37	504	582	247	1,609,413	6,459	4,864	+ 32.8	20,082,007	17,685,589	11		3	61	75	67	11	32	593	703	621	547	531	622
Pennsylvania	18		38	7	8	71	71	95	220,820	716	913	— 21.6	2,135,202	2,353,737			2	1	3			4	22	26	39	213	213	187
South Dakota							1	2		6	41	— 85.4	26,804	140,675									6	6	39	2	4	2
Tennessee			1	4		5	5		6,000	55			68,750					2	2				22	22			
Texas	769	26	86	421	27	1,329	1,487	1,471	5,765,285	15,940	19,780	— 19.4	67,532,749	83,303,649	26	2	2	247	277	278	42	77	3,271	3,668	4,612	1,093	1,014	1,250
Dist. 1: South Central	38	2	3	21		64	72	74	156,924	881	1,171	— 24.8	2,154,023	3,033,635				11	11	10	1	2	282	295	338	38	35	47
Dist. 2: Middle Gulf	13	7	10	23		53	54	55	340,783	643	708	— 9.2	3,940,547	4,290,547			1	17	18	11	8	11	197	227	246	32	30	39
Dist. 3: Upper Gulf	43	3	4	49		99	122	122	659,505	1,172	1,527	— 23.3	7,544,596	10,040,439	1			23	24	10	6	10	295	321	403	107	93	106
*Gulf of Mexico							2	1		11	10	+ 10.0	86,749	76,651						1		1	7	9	5			1
Dist. 4: Lower Gulf-S.W.	18	12	7	29		66	60	91	349,929	1,030	1,303	— 21.0	5,347,492	6,855,462	1		1	20	22	20	11	7	374	412	412	87	59	60
*Gulf of Mexico				1		1		1	8,748	8	20	— 60.0	84,048	193,945				1	1				3	3	3		1	2
Dist. 5: East Central	3	1	3	6		13	15	10	66,443	179	153	+ 17.0	676,493	689,170	1	1		6	8	3	2	1	98	104	110	16	11	10
Dist. 6: Northeast	32	1	8	30		71	67	72	418,243	766	983	— 22.1	4,097,390	5,327,608	1	1		15	17	7	5	3	175	190	231	58	62	59
Dist. 7-B: North Central	77		5	79		161	193	193	487,694	1,980	2,491	— 20.5	6,301,033	8,289,396	9			56	65	71	3	8	624	696	935	93	87	121
Dist. 7-C: West Central	35		4	11		50	69	89	212,548	707	1,078	— 35.0	3,446,592	5,047,320	1			7	8	27		8	166	201	310	57	67	82
Dist. 8: West	255		7	46	8	316	359	396	1,742,599	3,858	4,609	— 16.3	18,738,676	22,521,696	9			31	40	72	1	6	409	481	486	369	308	372
Dist. 9: North	177		17	169	18	321	353	266	873,897	3,494	4,407	— 20.7	9,907,948	11,760,499	1			55	56	35	2	6	561	604	997	146	169	233
Dist. 10: Panhandle	78		18	18	1	115	123	103	456,720	1,230	1,341	— 8.3	5,377,959	5,447,877	2			6	8	12	3	15	97	127	144	90	93	121
Utah	12			12		24	31	36	128,576	370	249	+ 48.6	2,053,883	1,366,083				7	7				78	78	108	39	41	62
Washington							1			6	4	+ 50.0	33,282	20,459									5	5	3	1	1	1
West Virginia	16		44	11		71	72	55	181,200	763	606	+ 25.9	2,043,863	1,661,307									6	6	24	213	216	175
Wyoming	19		11	35		65	50	68	304,242	637	740	— 13.9	3,003,384	3,311,309	1			21	22	11		3	186	200	247	115	118	96
Others			4	8		12	8		38,649	43	6	+616.7	181,610	27,848				6	6			1	23	24	6	4	4	5
Total United States	1,960	52	367	1,521	104	4,004	4,344	3,967	15,944,684	44,060	48,838	— 9.8	178,711,144	201,497,428	68	4	12	736	820	675	80	204	7,997	8,956	10,453	4,410	4,338	4,889
Total Western Canada	150		10	60		220	239	289	1,200,000	2,363	2,814	— 16.0	11,923,623	13,119,524												219	177	162

* Gulf of Mexico wells are included in their respective district total.

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HOUSTON, TEXAS

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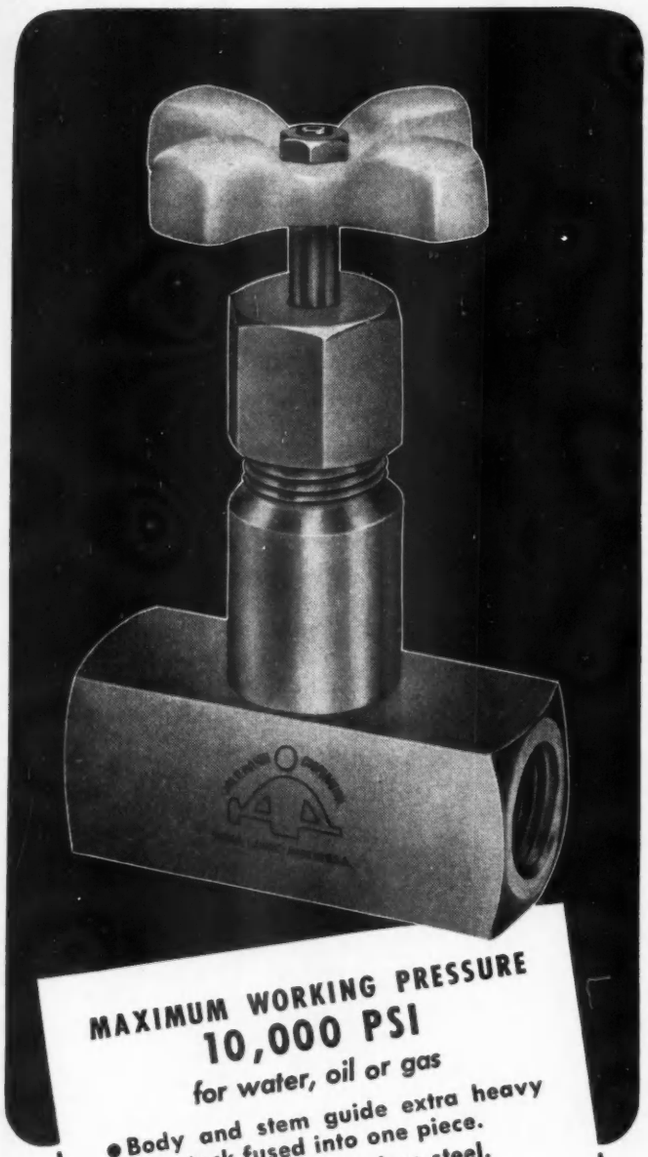
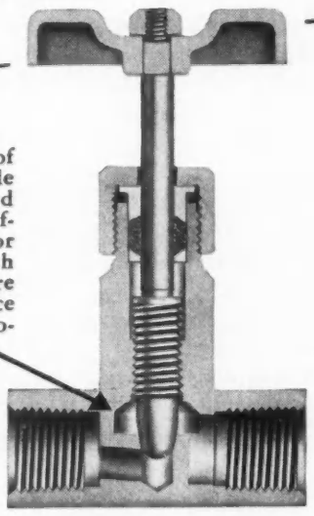


MAXIMUM WORKING PRESSURE
10,000 PSI
for water, oil or gas

- Body and stem guide extra heavy bar stock fused into one piece.
- Valve stem 416 stainless steel.
- Packing special one-piece "Marpak" moulded ring.
- Bodies marked in accordance with MSS regulations.



ONE PIECE

The stem guides of conventional needle valves are screwed into bodies—this often causes leakage or blow-outs. Marsh Needle Valves are fused into one-piece by exclusive "Conoweld" process.

The Ultimate in Needle Valves

Here is one of the crowning achievements of Marsh research, design, and manufacturing skill. It is the first needle throttling and shutoff valve to combine *all* of the qualities called for today in this highly critical and ever broadening field.

It is a valve that has strength and safety to spare . . . rated for pressures up to 10,000 psi—equally efficient in the lower ranges. A product of Marsh instrument-making and valve manufacturing experience, it combines instrument-like precision with the ruggedness that distinguishes all Marsh valve specialties.

The illustrations tell the story of new thinking; new standards. Body and stem-guide are machined from extra-heavy carbon steel bar stock. Still greater strength and rigidity are achieved by fusing the stem-guide into the body. The complete fusion of guide and body is accomplished by the exclusive Marsh "Conoweld" process.

There are two big advantages to this one-piece construction: (1) It eliminates the danger of unscrewing the valve from the body when opening—a frequent cause of leakage, even dangerous blow-outs (2) It permits perfect line-up of threads and seat. As a result, Marsh valves are easier to operate even at high pressures.

The precision-machined stem is 416 stainless steel. Stem threads are fine pitch for extra strength and fine, controlled regulation. Notable advancements are special "Marpak" one-piece, non-binding longer-lasting packing; deep thread chambers, keeping inlet and outlet piping away from ports and contributing excellent flow characteristics. Entire packing nut and packing gland are electro-zinc plated, preventing corrosion and giving the valve a handsome, plated exterior. The rugged malleable handle is finished in heavy baked enamel.

The new needle valve line includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1". Also globe and angle valves with male inlet and female outlet in sizes ¼" and ½". *Complete stock carried at our Skokie, Illinois factory and also at our branch plant in Houston, Texas.*

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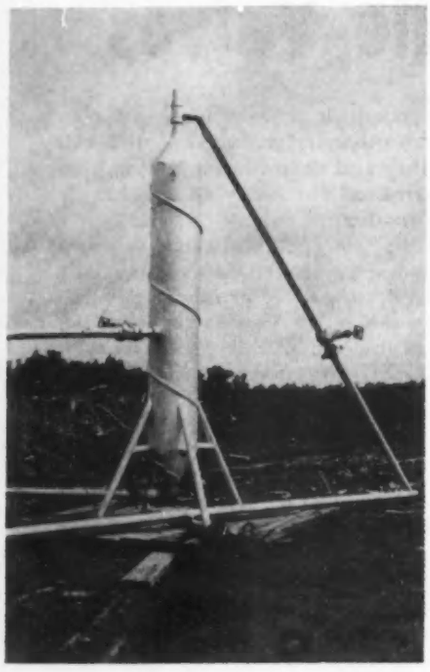
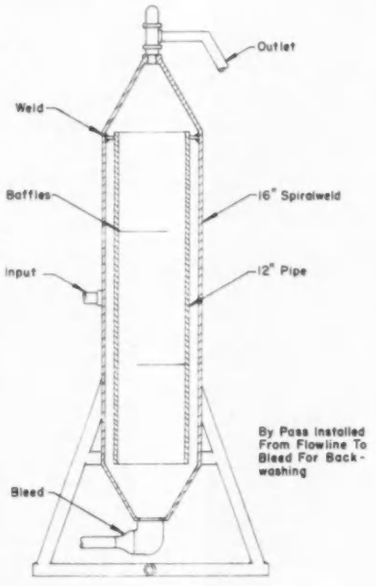




Build Sand Trap From Junk Material

This vertical sand trap was constructed in the field with junk materials found on the lease. A welder and helper comprised all labor required for the job.

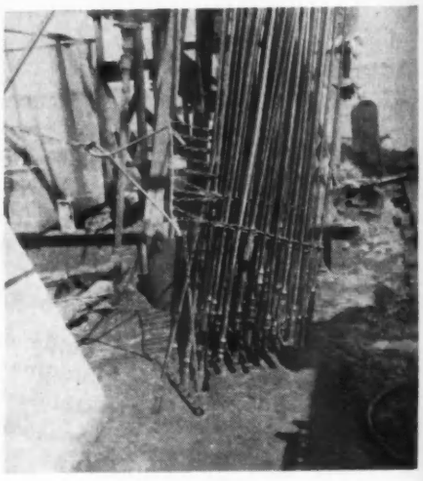
The trap shell is made from 16-inch spiralweld conductor pipe. A section of 12-inch casing or pipe is used inside the spiralweld as shown in the drawing. The 12-inch pipe is inserted in the 16-inch pipe prior to orange peeling the ends of the larger casing. The 12-inch pipe then is welded into place at the top of the vessel. Two baffles are provided in the 12-inch pipe as indicated. Legs are made from junk 2½-inch tubing and are welded directly to the spiralweld pipe. The inlet and outlet connections were made from 2½-inch tubing collars. A 4-inch bleed connection is provided for sand removal by back washing.

Fluid enters the unit at the side input as shown on the drawing. It then is directed downward since the top portion of the 12-inch pipe is welded directly to the spiralweld. As the fluid falls to the bottom of the trap, sand settles out. The fluid then must pass up through the baffled 12-inch pipe to the outlet connection. This allows additional "fall-out" of sand. When large quantities of sand have accumulated in the bottom of the trap, salt water is pumped back through the outlet flow line to flush the vessel through the bleed line. The bleed line runs directly to a burning pit where oil, salt water and sand are safely deposited.

Rod Hold-Back Device Saves Crew Time

A sucker rod hold-back device which offers several operating advantages, not the least of which is low initial cost, can be built easily by a welder out of scrap sucker rod and several dollars worth of light chain.

Shown in the accompanying photograph, the device consists essentially of a triangular framework of sucker rod material to which is attached, at evenly spaced intervals, a series of chains about 10 inches long. To the end of each chain is welded a 2-foot round bar to which are welded eight hooks, the latter being of a size to accommodate a single rod. The entire unit is held in position by a length of chain looped around a derrick leg or any convenient post. The installations shown, with 11 segments and 8 loops on each, provides space for 88 stands or singles. Any size or capacity unit can be built, however, to suit the average well depths involved.



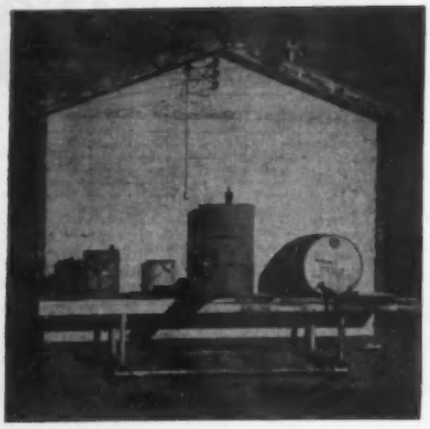
Among the advantages of this type unit are ease of rigging and transporting; flexibility of handling any number of rods, the unused segments merely hanging down out of the way when not used; ease of inspecting pins and boxes since the individual rows can be "parted" to gain access to rods in the middle or far back side; and, unlike the situation that exists when rods are pulled back in a single "bundle," the present system permits fast, accurate tallying.

Build Storage Bench On Doghouse Skid

Here is a unique method of constructing an outside storage bench for chemicals, paint, oil etc. on a

H C Smith 3-CUTTER ROCK BITS

COMPTON, CALIF. • ODESSA • HOUSTON • DALLAS • OKLAHOMA CITY • GREAT BEND • EDMONTON



skid-mounted doghouse.

In many areas, temporary skid-mounted units such as the one shown in the photograph are used for field offices, pumpers' doghouses, roustabout dressing rooms etc. This house has been equipped with a storage shelf completely across the rear portion. Two vertical risers made of junk 2-inch line pipe were welded on each of the two extended skids illustrated. Two pieces of right angle, steel strap then is welded on each of the risers. The boards forming the bench proper are set in place and bolted to the right angle straps.

If necessary, the doghouse, complete with bench, can be moved by truck to a different location with little effort. The bench also acts as a safety feature because toxic chemicals do not have to be stored within the house where field personnel are working.

Hinged Mesh Guard Covers Starting Pulley

The exposed starting rope pulley on an air-cooled auxiliary portable pump engine, a potential hazard for field personnel who might get their clothing entangled in it, takes on added importance when the unit may have to be left unattended where unauthorized persons might get too near it.

One welder solved the problem by fabricating an inexpensive hinged wire hardware cloth guard which completely covers the pulley. Using a light steel ring, such as a section of light pipe or a casing thread protector of the proper diameter, he wrapped the hardware cloth over the front, welded it and equipped the unit with a sturdy hinge and latch.

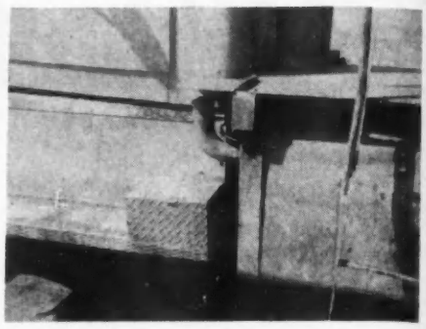
Welded to the engine housing, the bar stock brackets are sufficiently sturdy to withstand the vibration and rugged service to which such units customarily are subjected in the field. The cover swings open sufficiently far to offer no interference with normal engine starting procedures.

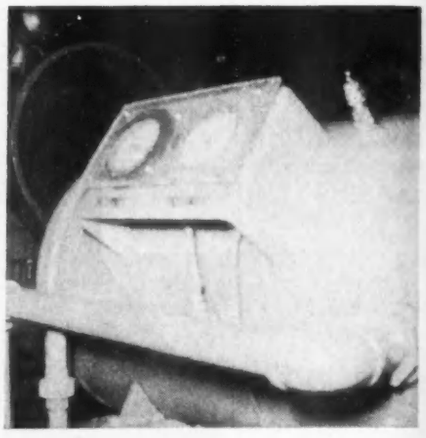
Protect Filler Neck With Hinged Plate

The fuel tank filler neck on a well pulling unit is a vulnerable point when it is considered that crew members have to avail themselves of every possible type of step in climbing up into certain parts of the unit for servicing or repairs. In its normally exposed position it also is subject to possible damage by falling tools or fittings.

One company, in protecting the filler neck on a tank immediately adjacent to the cab running board, extended their diamond plate decking over the exposed neck, cutting off and equipping the projecting portion with a heavy hinge. A gusset on the under side of the plate prevents the plate from falling below the horizontal and lends sufficient strength to support the weight of a man.

The inexpensive precautionary measure is good insurance against the work and trouble that would be involved in removing the tank and replacing a damaged filler neck.





Protect Air Gages With Glass Plates

These glass plates have been used to cover air gages as is shown in enclosed picture. This plate protects the gages from breaking and from water entering them while the rig or nearby equipment is being washed.

Walk Supports Give More Road Clearance

Supports that are amply sturdy to support the angle-iron re-inforced expanded metal walk at only two points, yet which can be folded back to give maximum road clearance, are illustrated in the accompanying photograph. Employing a double hinge principle to enable folding it back into a minimum space,

"CORES, PROOF from the PAY ZONE"

When so much time and money are invested for one purpose—to locate oil—we can't afford to guess about the productivity of a few feet of rock. We know from experience that the success of the entire venture depends upon complete information on the possible pay zone.

And there's no need for guesswork when coring delivers lasting physical evidence of the production potential of the reservoir. Information on storage capacity, permeability, formation fluids, fractures, fluid contacts, rock types and characteristics is readily available to the analyst, enabling him to forecast more accurately the primary and secondary performance of the well.

To assure highest core recovery, Christensen core barrels incorporate a stabilized, ball bearing suspended inner barrel which receives and protects the core from washing, blocking or friction grinding. Working with the smooth cutting diamond core bits, these barrels deliver top quality cores in all types of formations.

Whether you are planning to core hard, friable or soft, unconsolidated formations, there is no need for guesswork. Let Christensen show you how to get more from your investment by obtaining complete, lasting evidence of the formation below your rig. Christensen Diamond coring equipment gives you the greatest amount of core recovery at "Less Cost Per Foot."

A complete line of conventional, rubber sleeve and wireline core barrels is available. For information on these and a complete line of diamond coring bits — Write or call Christensen Diamond Products Co.

Diamonds Mean, "Less cost per foot."

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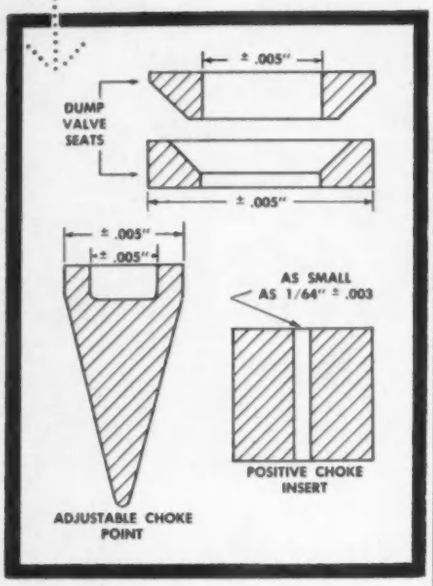
Here's How CMC Hard-Trim Can Trim Your Operating Costs



Impingement of abrasive oil and gas flow on control valves and orifices causes rapid wear, frequent lost production for maintenance and repair. A few dollars invested in precision-cast tungsten carbide hard-trims for these troublesome wear spots can save you hundreds or thousands in down-time.

CMC Tungsten Carbide Castings are not to be confused with conventional hard-facing materials or sintered carbides. They are *cast* to extremely close tolerances and provide a density and wear resistance not available in other materials.

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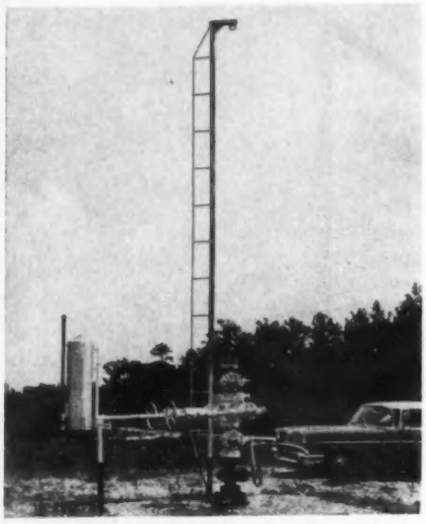
101

the main support arm is a section cut from heavy steel plate, the latter being hinged to a bracket cut from similar heavy plate material and welded permanently to the trailer frame.

At the outer tip of the folding arm and hinged in a horizontal plane, is another but smaller folding segment. This shorter arm extends up to and becomes the point of support of the walk. In the collapsed position for over-the-road travel, the hinged walk swings upward against the side of the trailer and the two brackets, folded at their two hinged points, are pushed back into the area beside the frame.



Permanent Gin Pole Saves Rig-Up Time

The gin pole shown is used to rig up wire line tools for paraffin scraping purposes, permanent completion work and various other downhole wire line operations. The pole is permanently installed on each well in the field which requires wire line work.

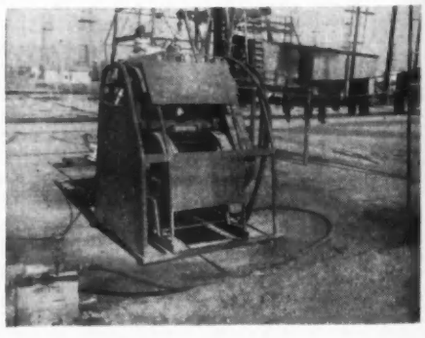
The gin pole is constructed of discarded 2-inch line pipe or tubing, ½-inch pipe or sucker rods and a small quantity of plate steel. As indicated in the photograph, the ½-inch material is used to construct the ladder portion while the 2-inch pipe serves as the main member. A small piece of plate steel is welded to the bottom portion and to the section immediately opposite the top-most flange in the tree. These pieces of steel have holes in the outer end, which allows them to be secured to the tree by means of the studs used in the flanged connections. This securely holds the pole in an upright position at all times. Other small portions are used as bracing material and as an eye on the top portion of the pole.

The gin pole is quickly and easily constructed in the field with the aid of a welder for a short period of time.

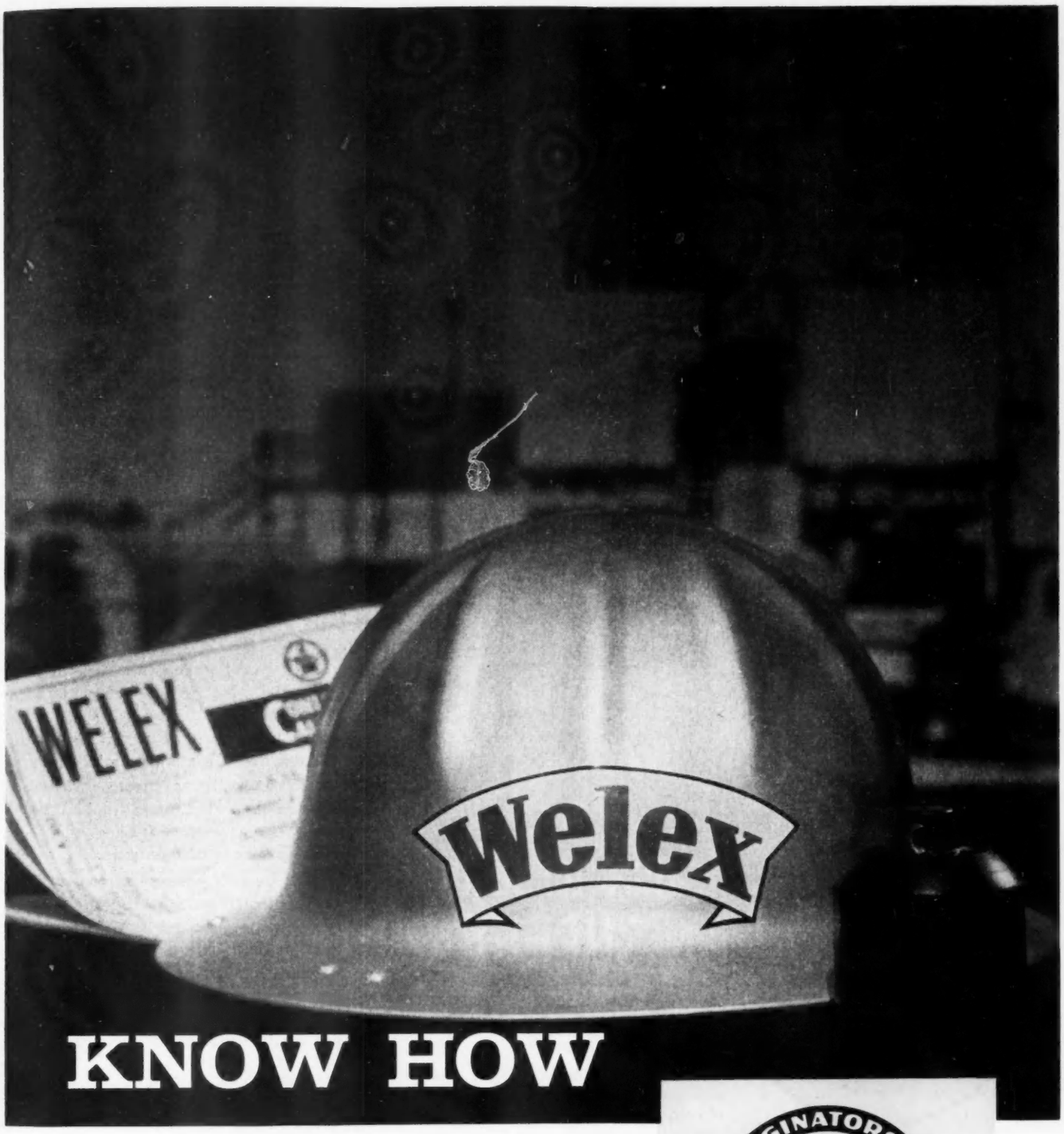
Unitized Washer Serves Needs of Drilling Crews

Combining the efficiency to be found in the modern commercially available industrial type washing machine with the portability and ruggedness necessary for oil field operations, a washing machine that is moved and hooked up easily is provided for crew members by one contractor.

The machine, just large enough to handle the daily washing needs of rotary crewmen, was mounted on a channel iron base. A pipe framework some foot or so larger in dimensions than those of the machine, was built around the unit and, for additional protection, sheet steel panels were welded to front, sides and top. To facilitate loading and unloading, a length of steel plate serving as a bail was welded across the top of the unit. A series of large holes cut in the plate permits easy attachment of hooks or sling.



In operation, it is necessary only to hook up the unit to power and water. In the installation shown, the waste water problem was handled by mounting the unit over the cellar of a nearby producing well. Long lengths of electrical cable and water hose permit reaching moderate distances for power and water in selecting a convenient spot for the machine.



KNOW HOW

It's what is under the hat that counts. That's why so many oil men choose Welex. Wearing the hat with the Welex emblem is a man with the "know how" to do the job right and fast. This "know how," backed by years of research and on-the-rig experience, means money in your pocket.

Whether it is perforating, logging or auxiliary services, Welex on the job means the team with the "know how" is working for you.

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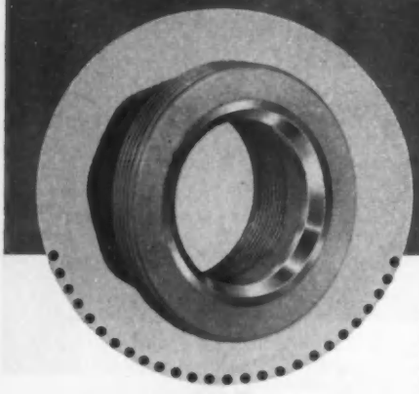
feature for feature are SUPERIOR



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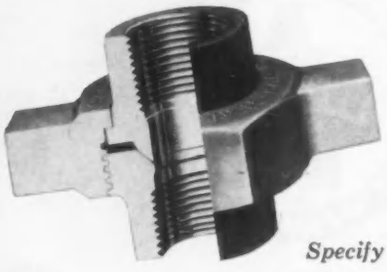

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Safety Screen Prevents Accidents on Pumping Unit

The screen guard shown is an excellent safety measure applicable in any field where pumping units are in use.

This guard makes it impossible for a man to work on the counter-balance side of the pumping unit prime mover. The possibility of injury due to the counter-balance is eliminated.

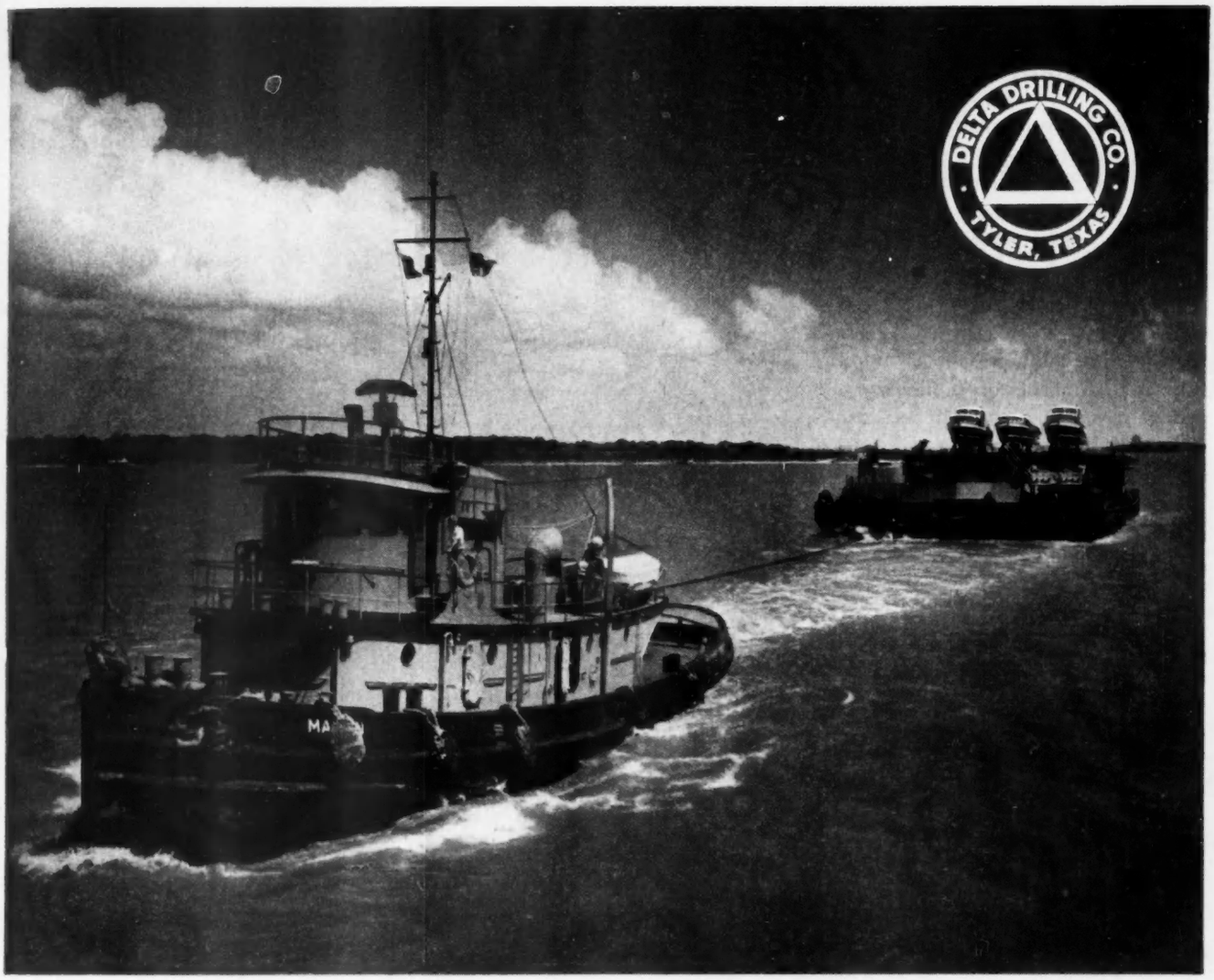
The guard is constructed as an integral part of the normally installed safety fence found around most units. Scrap pipe (2 inch) may be used for a frame work for both guard rail and screen. After the frame is constructed, ¼-inch expanded metal is tack welded in place. The screen and fence are then installed on location.

If it becomes necessary to work on the protected side of the engine, the mechanic or pumper is aware of the counter-balance, since the screen must be removed for access. The assembly and rail are mounted in 2½-inch nipples set in the concrete foundation and are easily removed if necessary.

Operator Builds Unusual Desander Hook-Up

Many rigs have now gone to the rig built desander in order to maintain the sand content of the mud at a desirable level.

One operator, however, found his rig set-up would not allow him to use a desander in the regular way. He set his desander on the horizontal and built a wooden V-trough to carry the desander discharge across the pit and into the sand pit. To facilitate the flow of the discharge, a small stream of water was allowed to flow in the trough.



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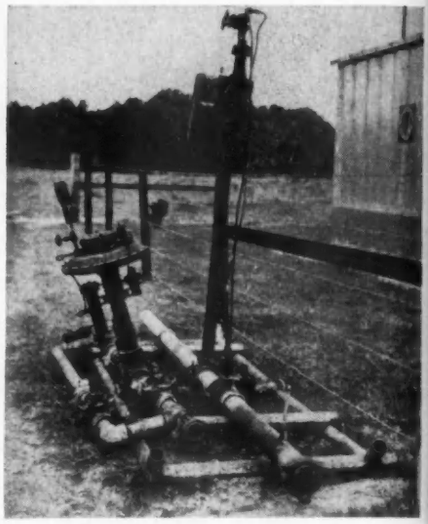
For more data on advertised products, use Readers' Service Cards, last page.

Valves Available For Immediate Use

In order to insure ready availability of replacements for key valves in high pressure mud lines and manifolding where cutting-out might occur at any time, one contractor keeps one or more spares mounted on nipples welded to any convenient out-of-the-way housing or framework.

In the installation shown, nipples were welded to the top of the lube oil storage reservoir. Carried in this manner, the valves will stand less chance of being misplaced or used for some other purpose; also are less likely to receive damage in rough handling which might occur were they carried in a bin along with other miscellaneous parts and fittings.

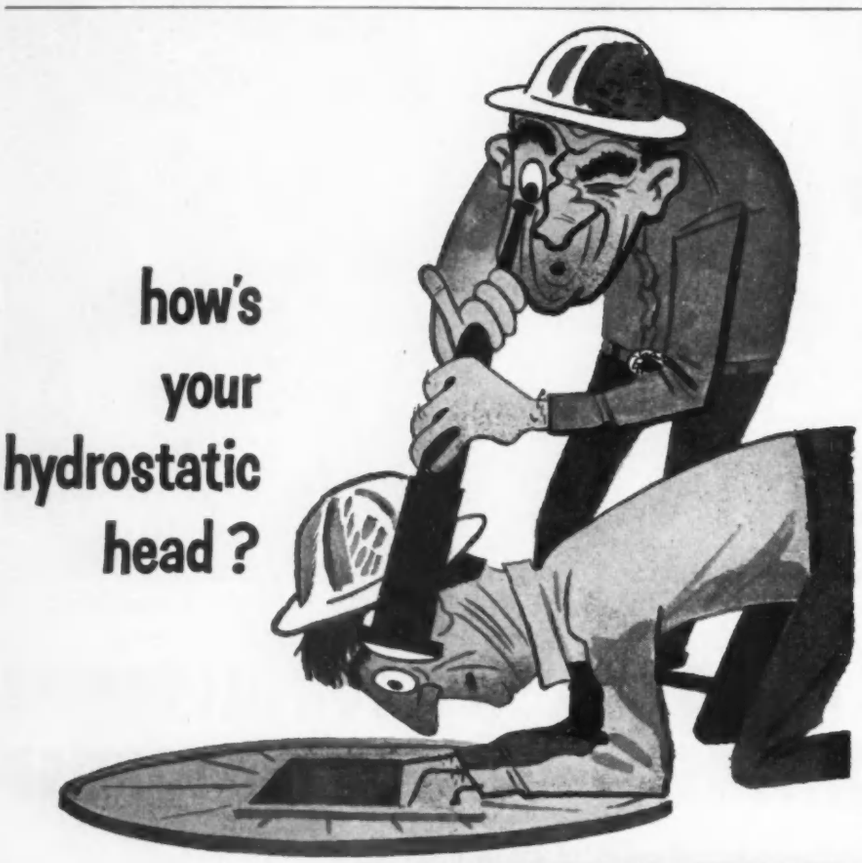


Skid-Mount Increases Meter Run Portability

The skid-mounted portable meter run illustrated is very useful for testing wells in isolated or wildcat locations where permanent producing facilities are not available. The skid-mount provides an easy means of transporting the meter run by truck. A conventional run is secured to the skid-mount by U-bolts as shown. The meter is removed before transporting the run and is shipped as a separate item to prevent breakage.

The packaged back-pressure valve unit illustrated is used in conjunction with the meter run. The motor valve is installed down stream of the meter run by the union connection. Any desired back pressure is held on the test line (within the limits of the regulator pilot) by the regulator. The test line also is equipped with unions to facilitate quick make up and break out.

The skid portion of the unit can easily be constructed in the field or shop. Two-inch pipe is welded as shown to form the skid proper. Conventional connections and valves are used to construct the regulator package.



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SEE WHAT'S HAPPENING DOWN THE HOLE WITH Pit-O-Graf

(Records mud pit level)

From the Pit-O-Graf chart you can calculate effectively any loss in hydrostatic head due to gas or salt water incursion. The continuous mud pit level chart warns of blowouts or threatened blowouts and loss of circulation.

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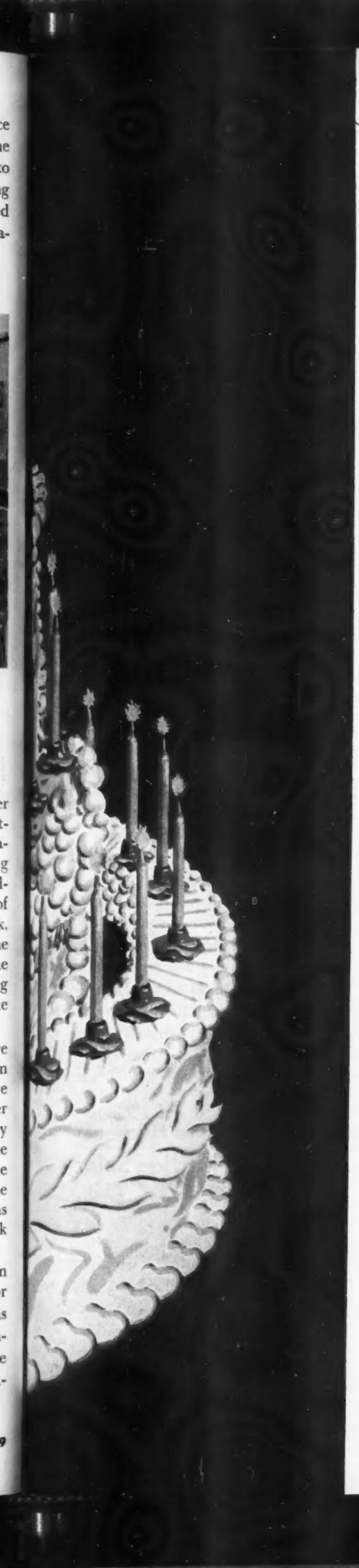

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Even the candles on the petroleum industry's 100th birthday cake are symbolic of the enormous growth of this basic industry that provides the world with a myriad of products from candle paraffin to rocket fuel.

Just as we're sure that the oil industry has been largely responsible for our growth, there is pride in our knowledge that we, in turn, have contributed in some small way to the growth of the oil industry.

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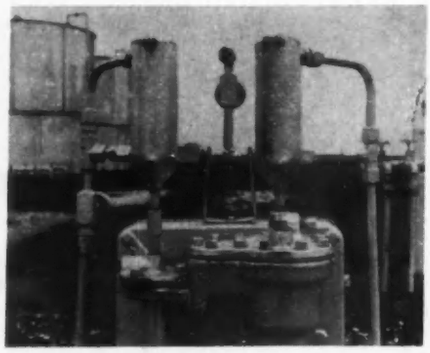
ROCKWELL MANUFACTURING COMPANY, PITTSBURGH 8, PA.

Field-Made Meter Drip Pots Prove Successful

The orifice meter drip pots shown are easily constructed in the field from a short section of 2-inch line pipe or tubing. Reasonably good pipe should be selected if the pots are to be used on a high pressure gas line.

Two sections of pipe approximately 6 to 8 inches in length are orange peeled as illustrated. A piece of steel plate is used to blank off the opposite end. Two ¼-inch connections



are provided at the top of the pots. Two ¼-inch nipples are welded to the orange peeled portion so the pot may be attached directly to the ¼-inch meter tap. These homemade pots serve the same purpose as factory made units. These installations shown have operated satisfactorily for several years.

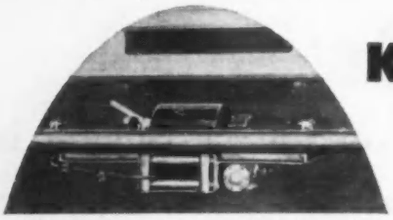
Make Walkways Safer With Non-Skid Coating

Here is a novel idea which is applied to walkways or other smooth surfaces over which field personnel must travel. A cup of very fine sand is added to a gallon of green creosote before applying to the smooth surface. The mixture should be stirred constantly while it is being applied to prevent the sand from settling out. When dry, the mixture forms an excellent non-skid surface.

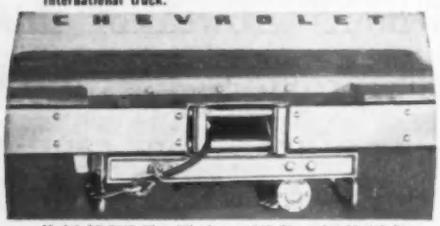
Application of this idea can virtually eliminate accidents due to slick or wet walking surfaces. Green creosote adds to the appearance of the job. If large quantities of the creosote mixtures are required, the same proportion of sand to creosote (one cup per gallon) should be maintained. This is a cheap, easy method for making walking surfaces safe in all types of weather.

Ladders on Line Heaters Save Time, Provide Safety

Ladders installed near the water-fill hatch on indirect line heaters save time and provide an excellent safety measure. Indirect line heaters require frequent addition of water for optimum operation. Heaters that are not equipped with a ladder as shown sometimes present a problem to field personnel who keep the water bath liquid level at the proper level.

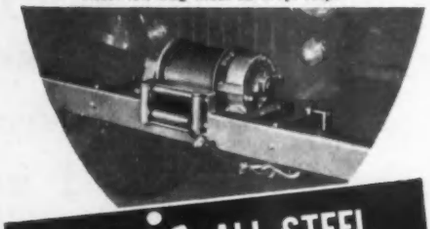


Model A-11 King Winch on A-120 (4x4) all-wheel-drive International truck.*



Model CD-8116 King Winch on 1958 Chevrolet Model 31 (4x4).

Model 151J King Winch on Willys Jeep.



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- bronze-bushed, 4-way cable guide rollers
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- heavy-duty pipe bumper
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King Winches keep you moving through the most difficult terrain . . . you get action where there's no traction with dependable pulling power. King power winches have pulling capacities of 8,000 to 19,000 lbs.

* *King Winches for International trucks are available through International-Harvester dealers.*

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FULL AND HALF CABS

Koenig Jeep cabs and King Winches for Willys vehicles are available through Willys Motors, Inc., and Willys-Overland Export Corp. distributors or dealers. Write for free descriptive literature.

Full Cab and Model 151J King Winch illustrated.

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HOMCO WHIPSTOCK—When sub-surface conditions warrant the use of a Whipstock, the HOMCO Whipstock offers Dependable Service.

HOMCO SPUD BIT—Used to drill a full gauge directional hole.

HOMCO Directional Drilling Services are built around tools which have been designed and engineered by HOMCO Engineers. Continuous improvement, through research and development, keeps the tools apace with the modern drilling practices. HOMCO offers the industry the most complete selection of Directional Tools and Services. Consult with HOMCO on your next Directional Drilling problem.

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New design uses an explosive pellet in the hollow connecting stems. This assures complete disintegration of the entire jet gun assembly upon detonation.

PERFORMANCE:

Laboratory tests by a major oil company, shooting under simulated well conditions into Berea sandstone targets of approximately 300 millidarcy permeability, yielded the following results:

2⅛" O.D. 24 gram charge, spaced 2" from the target face

- Penetration— 7½ inches
- Well flow index 1.5 (151% of open core flow)
- Clean hole— no carrot plugging
- Excellent breakup of case and stem

1 11/16" O.D. 13.2 gram charge, spaced ½" from the target face

- Penetration— 6¾ inches
- Well flow index 1.37 (137% of open core flow)
- Clean hole— no carrot plugging
- Excellent breakup of case and stem

Explosive type spacer pictured at left allows charge spacing or skipped intervals as desired. Any length of blank spacers may be used with disintegrating explosive cord through the entire length to eliminate debris or bridging problems in such skips.

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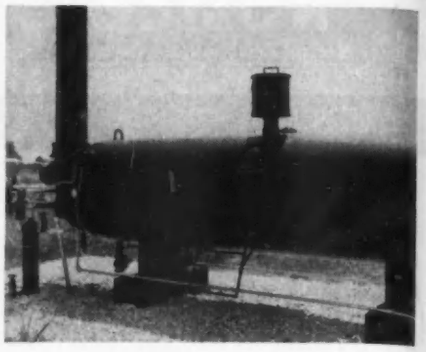


If one man is charged with this responsibility, it is very awkward to climb the "hot" vessel with a pump hose or bucket of water.

By constructing a ladder of ½-inch sucker rods or pipe, the operation is simplified considerably. The pumper simply climbs the ladder and performs his duties with a minimum of danger and no loss of time. Four couplings welded to the heater shell form receptacles for the ladder legs as illustrated. The ladder is easily removed if the heater is transferred to another location.

Extra Valve Safeguards Against Fire-Blowouts

A safeguard against blowouts and possible fire on a drilling rig is made possible by installing a valve between the fuel supply and engine. The driller operates the valve from his position at the brake; by closing the valve, the engine is killed immediately.

Courtesy of Falcon-Seaboard Drilling Co.

How-To-Do-It Ideas Earn Money, too!

WORLD OIL editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of your latest ideas and send them in with a picture or drawing of the installation . . . if accepted, $10 for each idea will be yours. Send those money-making ideas today to Hints Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

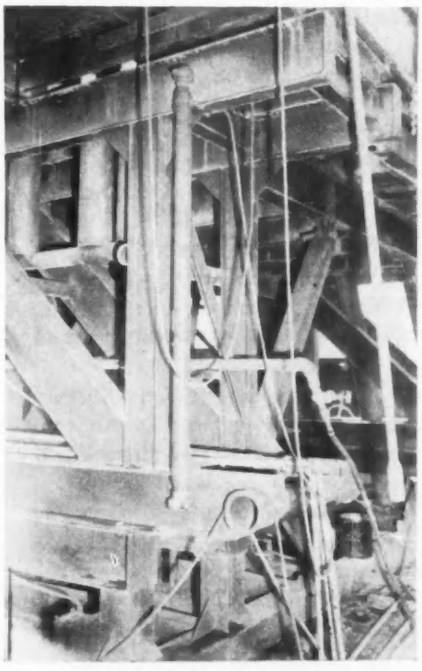
Safety Line Holds Drive Bushings Together

Here is a means of holding the drive bushings together, even though the "J" bolts are sheared due to rough drilling, reaming or from fishing operations. A ¼-inch steel line is laced through the eyelets on the top cover-ring and also through the hand-holds on the bowl and securely clamped off. The steel line, serving much the same purpose as safety wiring in aircraft, eliminates the possibility of the drive bushings coming apart and the heavy rollers falling on the crew members.

Permanent Pipe Section Aids Drillstem Test Flow Line

The drillstem test flow line between the well and sump can be rigged easier, faster and with a considerably greater degree of safety during the test, with the aid of an idea employed by one contractor.

At one corner of the rig substructure, as shown, is welded a vertical length of 3-inch pipe, each end being swedged down to 2 inches and equipped with a hammer type high pressure union. The upper end reaches to within a few inches of the underside of the rig floor; the lower end to within about 3 feet of the ground. To rig the flow line all that is necessary is to remove a floor cover plate and make up the line between the well head and the permanent riser; then make up the line from the lower end on out to the sump.



The permanent length of pipe, being welded to the rig substructure, eliminates the makeshift rigging of a line over the side of the floor and with the resultant hazards involved should the line start to jump and whip around under the impact of full well flow pressure. Although some anchoring or lashing-down of the line between the rig and sump is required, the permanent installation assures that no movement of the line can occur at this point.

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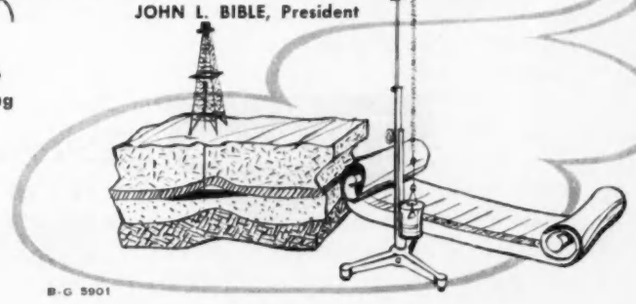

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OIL'S 100th Anniversary 1859-1959

FOREWORD

A Century of Oil

OIL AND GAS are the wonder fuels, lubricants and chemical sources of the modern scientific world. They furnish the lubricating oils so vital to the function of all mechanical machines, much of the heat that keeps man comfortable, and dominate the world's power energy picture today to an astounding degree. In addition, oil and gas hold an equally imminent position in the new and rapidly expanding chemical field, being the basic ingredient for such widely diversified products as plastics, synthetic rubber, fertilizers, modern cloths and many thousands of other useful commodities.

Exclusive of enormous volumes of natural gas, world consumption of petroleum products rapidly is approaching the amazing figure of 7 billion barrels annually. All this tremendous growth has taken place in the last century, for the first well to be drilled for oil was not completed until Aug. 27, 1859.

No other industry has been called upon to expand its facilities at such rapid rates in so short a period of time. This has been especially true during the last 25 or 30 years. Fifty percent of the world's growth in oil consumption has occurred during the last decade; three-fourths of the growth has been in the past 20 years. Oil and gas have met this gigantic challenge so successfully, supplies have been more than abundant in peacetime and ample during two world wars.

All this has been achieved despite the necessity of overcoming a host of extremely unique and hazardous economic and engineering conditions entirely different in character from those encountered by other industries. In addition, oil and gas have faced all the normal economic problems which confront other businesses. Specialized tools and techniques have been developed for remotely conducting operations at great distances beneath the earth's surface in the discovery, development and production of oil and gas. The industry has developed its own highly unique transportation system and its own equally unique refining (manufacturing) processes and practices.

The ability to supply such abundant volumes of oil and gas despite numerous peculiar factors is a remarkable story of how a highly competitive business system serves to promote great technical progress. It also is a story which proves that technological advancements are the best possible conserving and multiplying agents of a natural resource.

Were it not for tremendous technological strides, it would have been impossible to amply supply the world with such supplies of oil and gas. Nor could this have been accomplished at such reasonable prices. Along with recording spectacular technological advances, an entirely new and different business concept has been developed by oil and gas production in the United States. Output is regulated by state agencies without destroying any of the incentives attainable only through competition.

In view of the outstanding role technology has played in oil's development, it is fitting that a petroleum business publication like WORLD OIL should devote its Oil Centennial Anniversary Issue to the industry's technological progress and to what this has meant to the peoples of the world. Since WORLD OIL is edited especially to meet the interests of personnel directly engaged solely in exploration, drilling and producing phases of oil and gas, the

accompanying history is confined to the progress made in these activities. Advancements in refining technology have been equally significant and important, but this is a story which is being told in the January issue of PETROLEUM REFINER, another Gulf Publishing Company publication.

If this discussion serves to emphasize the importance of technology and competition in providing the world with an abundant supply of oil and gas under the most difficult conditions imaginable, WORLD OIL's efforts will be repaid many times. Toward this end, the work is dedicated to the numerous individuals, producing companies and manufacturing and service companies who have contributed so much in changing the industry's exploration-drilling-producing operations from the old haphazard, wasteful methods of the early days to the highly efficient scientific practices of today.

Thousands of hours have been spent in researching the industry's literature, both current and past. Innumerable books, magazines, association papers, and other publications served as invaluable sources. In addition, numerous companies and individuals connected with the industry courteously furnished a vast amount of data and photographs. To these, we gratefully acknowledge our indebtedness for their assistance and suggestions.

Many members of WORLD OIL's editorial staff participated in the extensive task entailed by such an undertaking. Only a few who made extensive contributions can be mentioned here. Months of uninterrupted research work was spent by Charles Aycock in gathering and consolidating much of the material, and in preparing rough preliminary background data. Don Lambert also took part in the gathering and consolidation of the material, in addition to rewriting the original preliminary rough material. Finally, besides directing all Centennial issue activity, Warren Baker rewrote all preliminary data into a new, completely revised, finished manuscript. In so doing, he called upon his knowledge of economic and technical phases, gained during nearly 35 years of close association with oil and gas exploration-drilling-producing activities. Last, but not least, Mrs. Mignon Vaughan is due credit for drawing most of the many sketches used to illustrate 100 years of technical progress in the discovery, development and production of oil and gas.

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OIL'S 100th Anniversary 1859-1959

CHAPTER I

The Emergence of Order Out of Chaos

LIFE a hundred years ago was a physically strenuous pursuit. Most work was done manually. Everyone—housewives, farmers, employers, workers, and children—labored long hours at demanding and tedious tasks.

Sustenance depended upon the food and shelter man could wrest from nature, mostly through his own strength and toil. He had the horse for transportation and for plowing the fields but little else to help him. Only a few possessed the recently introduced horse-drawn harvesters. Women made the family's clothes, milked cows, churned butter and even made the family soap.

All in all, 1850 differed little from the times of Washington, Caesar, and Christ.

But, in the 1850s, mankind was on the threshold of a century of progress which was to surpass all of history's advancements. A new lamp which burned coal oil or whale oil gave hope of a better illuminant than candles and the open fireplace. People still gaped in wonder when they infrequently saw steam engines turning the wheels of a few embryonic factories, or driving railroad locomotives and steamboats at then amazing speeds of a few miles per hour.

A growing need for fuel and lubricants. Numerous new inventions during the first half of the 19th Century led man to dream of a wonderful new world. But there could be no great social and economic stride unless a more satisfactory and abundant supply of illuminants, fuels and lubricants could be found.

Animal fats no longer could supply the need for greases, though demand was quite small. The whaling industry could not meet rising requirements for lubricating and illuminating oils. The price of whale oil had jumped to $2.50 per gallon, or $100 a barrel. Oil was being distilled from coal in small quantities for lighting purposes but it, too, was expensive.

Oil had been known since the beginning of history. The pitch used to caulk Noah's Ark undoubtedly was petroleum. Many other simple uses are recorded in the early pages of history and down through the centuries. Early American settlers found Indians skimming oil from seeps and using it for both internal and external medicine. A few enterprising American business pioneers were selling "Rock Oil" as medicine by the middle of the 19th Century. Their sources of supply were seepages or salt brine wells in which they were "unfortunate" enough to find oil.

However, no one gave any serious study to the commercial possibilities of oil until the simultaneous beginnings of the Age of Light and the Machine Age created the world's first and most serious oil shortage.

At that time, man was mostly interested in developing a source of lamp oil for better illumination so he would not have to go to bed at dusk. Colonel A. C. Ferris of New York by 1857 was experimenting vigorously with petroleum as an illuminant. He improved the kerosine lamp and the fuel he made from oil. His business grew and supply became his chief problem. Ferris bought oil from J. M. Williams, who had been digging oil pits near Hamilton, Ontario, Canada. The oil was shipped by train and wagon. Ferris also was buying oil obtained from pits and dug wells in California and the East Indies. He tried to develop his own supply by digging a shaft near Tarentum, Penn., but failed to find oil.

In other parts of the world, an increasing interest was developing in oil. Hand dug wells were being operated in Rumania and Burma by 1857.

The birth of oil. The discovery of an abundant supply of illuminating oil had to wait a little longer because of Ferris' failure to find petroleum. George H. Bissell, journalist and teacher, saw a sample of "Rock Oil"

during a visit at Dartmouth College in 1853, and was told it would make a better illuminating oil than coal.

Bissell was sufficiently impressed to visit oil springs on Oil Creek, Pennsylvania, and buy 100 acres of land. Returning to New York, Bissell and others formed the Pennsylvania Rock Oil Company. The company gathered oil from seepages on the Pennsylvania property, receiving a handsome price of $1.50 per gallon.

In 1855, Professor Benjamin Silliman was engaged by Bissell and his associates to analyze the commercial possibilities of their oil. Silliman not only verified that the oil would make a better illuminant but also reported it yielded gas, paraffin and lubricating oils.

Thus encouraged, Bissell and his associates decided to drill for oil, the same way others were drilling water and salt-brine wells. Some of the stockholders objected to this "wild gamble" so the company was reorganized as Seneca Oil Company.

Colonel Edwin L. Drake, a small stockholder in the company, became the first oil well drilling contractor when he was hired to drill the well on the company's property near Titusville, Penn.

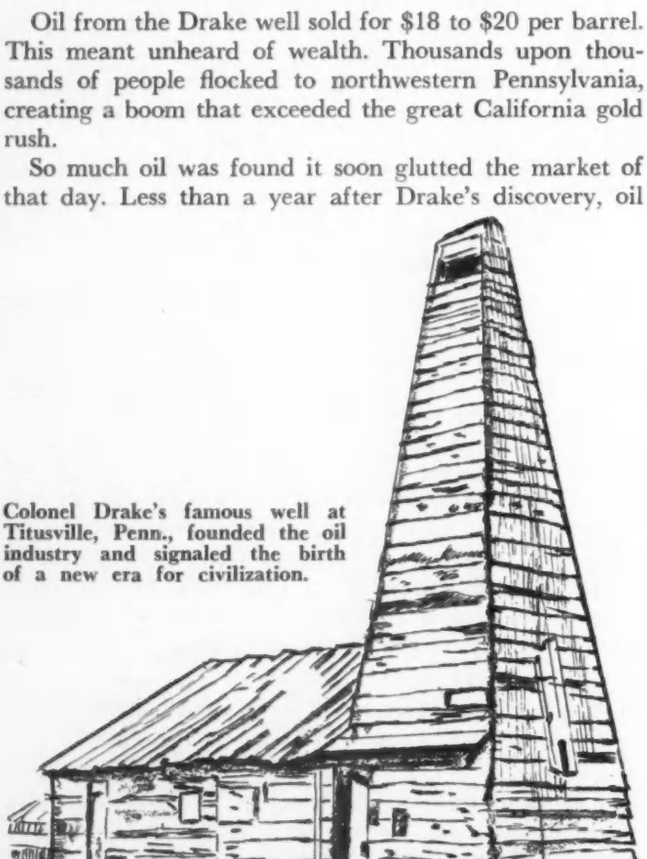
Drake, a railroad conductor, knew nothing about drilling wells. Therefore, he hired an experienced salt-well driller, William "Uncle Billy" Smith, who employed his two sons as the drilling crew.

On Aug. 27, 1859, oil was struck at a depth of 69½ feet. The well produced 15 to 20 barrels daily.

A NEW WAY OF LIFE FOR MAN

Oil from the Drake well sold for $18 to $20 per barrel. This meant unheard of wealth. Thousands upon thousands of people flocked to northwestern Pennsylvania, creating a boom that exceeded the great California gold rush.

So much oil was found it soon glutted the market of that day. Less than a year after Drake's discovery, oil was selling for $10 per barrel. At the close of 1861, just two years later, it was bringing 10 cents a barrel. The world now had an abundant supply of cheap illuminating fuel.



Colonel Drake's famous well at Titusville, Penn., founded the oil industry and signaled the birth of a new era for civilization.

Never was there a swifter transition of comparable importance in man's way of life. The extremely cheap price by 1861 ruined many hopeful oil producers, but its cheapness served to introduce the product to all parts of the world.

Two years after Drake proved oil could be found and produced by drilling for it, the cheaper and quicker Bessemer process opened the way for better steel. Only 11 years later, electricity came into use, although not yet for the average family.

With oil, better steel and electricity, man now possessed the materials and resources with which to create an easier and more abundant life for himself. The future would depend upon his own inventive ingenuity and skills. New wonders were to come with incredible rapidity. Civilization was to progress further in the next century than in the preceding 2,000 years. There was to be a sweeping revolution in manners, customs, mode of living, and in business affairs.

Oil's invaluable contributions. No single development is responsible for the great progress of man in the last century, but none has contributed more than petroleum. Expanded use of oil in competition with other fuels demonstrates beyond doubt that petroleum has served its consumers well.

Oil would have played an outstanding role had it contributed nothing but lubricants to overcome metal friction. Without oil, modern mass production and the whole machine age would grind to a sudden halt, destroying the world's economy.

But the swiftly mounting importance of petroleum in the modern world also must be measured in terms of mechanical energy. In 1900, oil and its sister fuel, natural gas, together supplied but one-twelfth of the power requirements of the United States; in 1930, almost one-third; and today they supply two-thirds. Coal, water and electricity combined to furnish the balance.

Oil and gas do not dominate the mechanical energy to such an extent in the rest of the world. However, they have made amazing progress since World War II, as the rest of the world turns increasingly to mechanized manufacturing and travel.

Perhaps the petroleum industry's most dramatic contributions have been in the transportation field. Abundant and low cost oil has resulted in the universal adoption of the automobile, truck, bus, airplane, and railroad. This has decentralized residential community and retail trade and has provided easy distribution of products and commodities.

Since 1935, food production of U. S. farms has increased about 50 percent, despite decreased farm population. This has been due largely to the adoption of mechanized methods. Oil performs many specialized farm tasks. It is used in insecticides, fungicides, disinfectants, weed-killers, and inexpensive chemical fertilizers.

Oil also heats a large portion of the homes. This is

especially true in the United States, but now rapidly becoming true in many other regions of the world.

Practically all cargo and military vessels are oil powered.

These are the things for which oil is best known. However, it makes countless other contributions in our daily lives. Among the thousands of products which depend upon petroleum derivatives today are such varied products as plastics, synthetic rubber, asphalt, shower curtains, linoleum, rubber and asphalt tile, rust inhibitors, antifreezes, food preservatives, paints, roofing and insulating materials, cold cream, hair-setting lotions, lipsticks, nail polishes, wax paper, dyes, nylon, rayon, dacron and orlon cloth, rubbing alcohol, shaving cream, printing inks, nasal sprays, telephone instruments, golf balls, fishing flies, etc.

Essential in war. In times of war, petroleum takes on an even more vital significance. Without oil, ships could not sail, planes could not fly, tanks and jeeps would be immobile. Even big guns would not shoot, and nonatomic bombs would not explode because the explosive agent in these shells and bombs is derived almost entirely from oil.

Two-thirds of all tonnage shipped to U. S. fighting forces overseas during World War II consisted of petroleum products. Weapons, ammunition, food and other supplies made up the balance. A thousand-plane raid on Berlin required 1 million gallons of gasoline.

AMAZING GROWTH IN OIL DEMAND

Such a versatile, inexpensive, convenient, and useful fuel as oil could be expected to experience an incredibly rapid consumption growth. However, the extent of this continued expansion can be described only as amazing.

The first real commercial use of oil was as kerosine to burn in lamps. In the early days, gasoline and other by-products were nuisances to be disposed of in pits or nearest waterways.

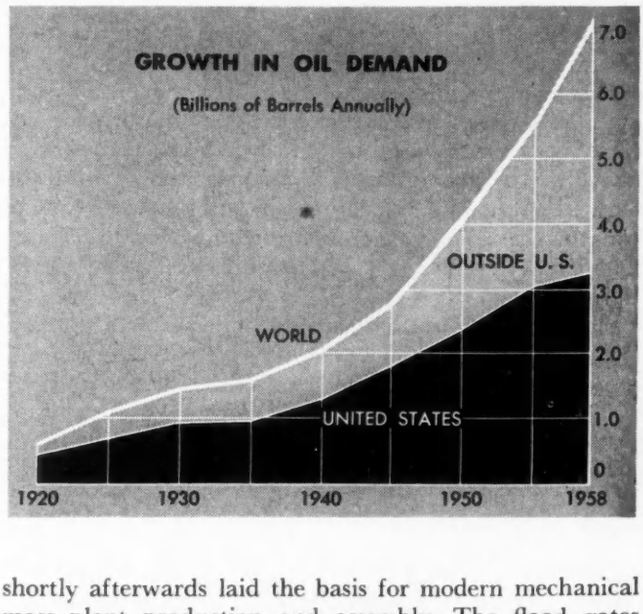
By 1870, lubricating oils were being developed on a widening scale. Metallic friction, the arch-enemy of machinery, was being overcome. The steam engine came into extensive use on railroad, ships and in plants as stationary power. Shortly before 1900, oil was beginning to be used as boiler fuel to generate steam, particularly by the railroads.

Oil consumption increased to 150 million barrels annually by 1900.

Gasoline becomes prime product. The early 1900s saw two developments of great significance for the oil industry. Electricity became kerosine's formidable competitor, and soon was to push kerosine into the background as an illuminant.

Meanwhile, progress in the development of successful gasoline and diesel burning engines was setting the stage for epochal developments in mechanization, including the automobile, airplane and mechanical power for all kinds of jobs. The gasoline era was beginning. Consumption of petroleum was to double in the next 10 years, in 1910 being slightly in excess of 300 million barrels annually.

In 1909, Henry Ford standardized his Model T, and



shortly afterwards laid the basis for modern mechanical mass plant production and assembly. The flood gates had been opened. Automobiles and hundreds of other products were to be within reach of the great multitude of ready buyers. Oil demand rose faster than ever, and gasoline was to become its chief product.

From 1910 to 1920, the number of motor vehicles was to increase from less than 500,000 to 9 million. In addition, oil became the universal means of powering ships immediately after World War I. The consumption of oil again doubled, rising from 300 million barrels to 660 million barrels between 1910 and 1920.

The automobile engine was not out of swaddling clothes before the Wright brothers used it to make the first successful flight of man in 1903. Aviation made phenomenal advances after World War I.

Almost simultaneously with the airplane came the introduction of another development which was to further boost oil consumption: the use of oil for heating. Kerosine was used widely as a heating fuel, and fuel oil had been used to a small extent for sometime. But with the development of the automatic oil burner in 1917, furnace drudgery was eliminated. Millions of U. S. homes were to come to use this heating method.

Growth rate spirals. The airplane and home heating created additional needs for oil, adding to previously existing uses which still were expanding by leaps and bounds.

Henceforth, the consumption of petroleum would be measured in billions, not millions, of barrels annually. World consumption of oil did not reach 500 million barrels per year until 1917, or 66 years after the Drake well gave birth to the industry. But, consumption needed only another seven years to reach 1 billion barrels annually.

With the widespread adoption of the automobile after World War I, hard-surfaced highways replaced the old rough dirt roads which too frequently became mud holes. As these new highways spread across the land, the expanding use of automobiles was phenomenal, both in

number and in volume of travel. Many highways were paved with asphalt made from petroleum.

During this same period, the machine age took over most industrial and farm activity, and the airplane became a common sight in the sky. More homes were heated with oil, and increasing quantities of oil were used in the manufacturing of electrical power. Annual consumption of oil rose from 1 billion barrels in 1924 to 2 billion barrels by 1940, then to 3 billion barrels by 1947.

Record growth in consumption. Oil's growth rate has been even more rapid in recent years. Consumption of petroleum soared to annual level of 4 billion barrels by 1950, then to 5 billion barrels by 1954, and on upward to 6⅔ billion barrels yearly by 1956. And, in 1959, just

Wanton waste of gas, characterized by burning flares in U.S. fields, has disappeared from the scene as growing markets increased its economic value and the industry came to fully appreciate the beneficial influence of gas energy in increasing oil recoveries.

100 years since its beginning, the consumption of petroleum will exceed 7 billion barrels annually.

A growth of 3½ billion barrels in oil consuming rates during the last decade represents half of the world's current consumption volume. In other words, oil consumption in the past 10 years has increased as much as in the industry's preceding 90 years of history.

Fastest growth outside United States. The most important of several factors responsible for the sudden surge in oil consuming rates during recent years has been a significant gain outside the United States. Since World War II, many areas of the world have adopted the automobile, truck, tractor, and airplane on an unprecedented scale. Simultaneously, these regions have mechanized their factories and adopted oil-burning stoves and furnaces.

Recent postwar years also have seen the replacement of the railway steam locomotive by diesel-electric locomotives. Furthermore, the petrochemical age really came into full bloom during and immediately following World War II.

From 1920 to 1945, while world oil consumption quadrupled, the U. S. consumed approximately twice as much oil as the rest of the world.

Tremendous postwar industrial and mechanization growth outside the United States has changed completely oil's consumption picture. The rest of the world now consumes more oil than the United States. Between 1945 and 1958, annual consumption abroad again has quadrupled, rising from 950 million barrels to approximately 3⅔ billion barrels. During the same period, U. S. annual consumption has nearly doubled in rising from 1¾ billion barrels to 3¼ billion barrels.

SPECTACULAR DEVELOPMENT OF NATURAL GAS

Another major contribution of the petroleum industry to man's great progress is natural gas. With good reason, oil and gas often are referred to as sister fuels.

Natural gas has been developed simultaneously with the oil industry, and by the same men and companies. One-third of the natural gas produced in the United States comes from oil wells, and the remainder from wells which produce natural gas without oil. The two are found under identical conditions, so when drilling on unproven locations it never is known whether oil or gas, or both, will be found.

Gas predates oil. Commercial utilization of natural gas predates the discovery of oil in Pennsylvania. As with oil, the first use of gas was as a source of light. A 27-foot well drilled at a gas seep produced a sufficient quantity to light the streets of Fredonia, N. Y., as early as 1824.

Early drillers seeking oil promptly found a far greater supply of natural gas than could be absorbed by nearby towns. Gas flares, or torches, became the familiar marks of an oil field. A system of controlling natural gas and conveying it through pipe lines was devised by George Westinghouse in 1885. And natural gas began to be used for both heat and light in homes and factories located farther from producing fields.

Gas also began to be used in the manufacture of carbon black shortly after Drake's discovery well. Carbon black was being used in the manufacture of ink as early as 1864. Carbon black became important in the manufacture of polishes and paints. However, the utilization of carbon black did not reach large volumes until automobile tires became an important part of man's life in the early 1920s.

Begin extracting liquids. Until 1900 it was not realized that natural gas contained other valuable components, including gasoline, propane and butane. Production of natural gasoline from natural gas began in 1908 with the building of the first compression plant in West Virginia. More than 250 of these plants were constructed in the next four or five years.

A more efficient method for extracting liquids from natural gas, the absorption process, began in 1913. This type of plant could extract liquids from drier gases than could compression plants.

In addition to extracting valuable products from natural gas, these plants served to improve gas as a heating fuel. Because of the drier nature of residue, gas from these plants was much safer and a more efficient heating

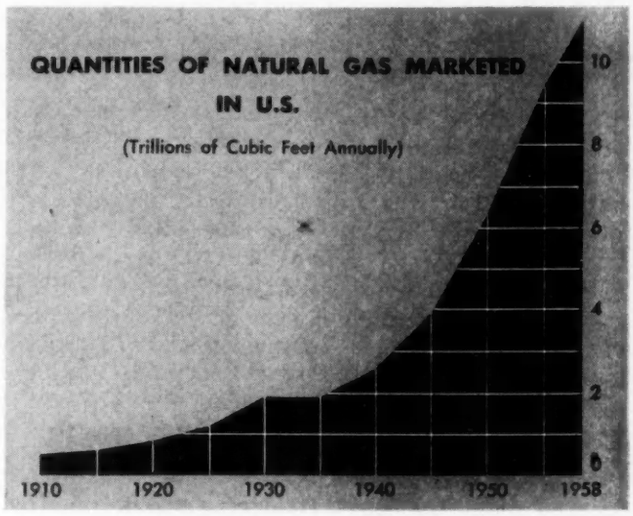
fuel. This encouraged the utilization of natural gas in homes and industrial plants.

Serious handicaps. Despite growing markets, far more gas continued to be found than could be used commercially. Consequently, wanton waste of tragic volumes continued to characterize the industry. The reason was that gas fields were located far from large, heavily populated and industrialized cities in the colder atmosphere of northern states. Since its nature made it impossible to store above ground and to transport by ordinary means, natural gas was too expensive to move to markets.

Another serious handicap in natural gas marketing was the exceedingly low price received by producers. Due to serious oversupply, the price of gas was too low to encourage producers to gather and prepare it for delivery to pipe lines.

Until the late 1920s, few gas pipe lines exceeded 250 miles in length. Many complex developments were required to make transcontinental gas transmission systems economically feasible. One of these, for example, was the introduction of welded joints which made pipe lines virtually leakproof. More efficient compressors was another advancement which encouraged the building of long gas transmission systems.

Greater utilization curbs waste. Natural gas utilization made great strides in the late 1920s and early 1930s. This was the result of technological progress coupled with the discovery of several very large dry gas fields. Discovery of the Panhandle (Texas), Monroe (Louisiana) and Hugoton (Oklahoma, Kansas, Texas) fields assured the existence of adequate supplies to pay out expensive long distance pipe lines. Large diameter pipe lines were laid from these fields, including an 1,855-mile line from the Panhandle area to Minnesota. During 1931 and 1932, more than 4,500 miles of natural gas pipe lines were laid.

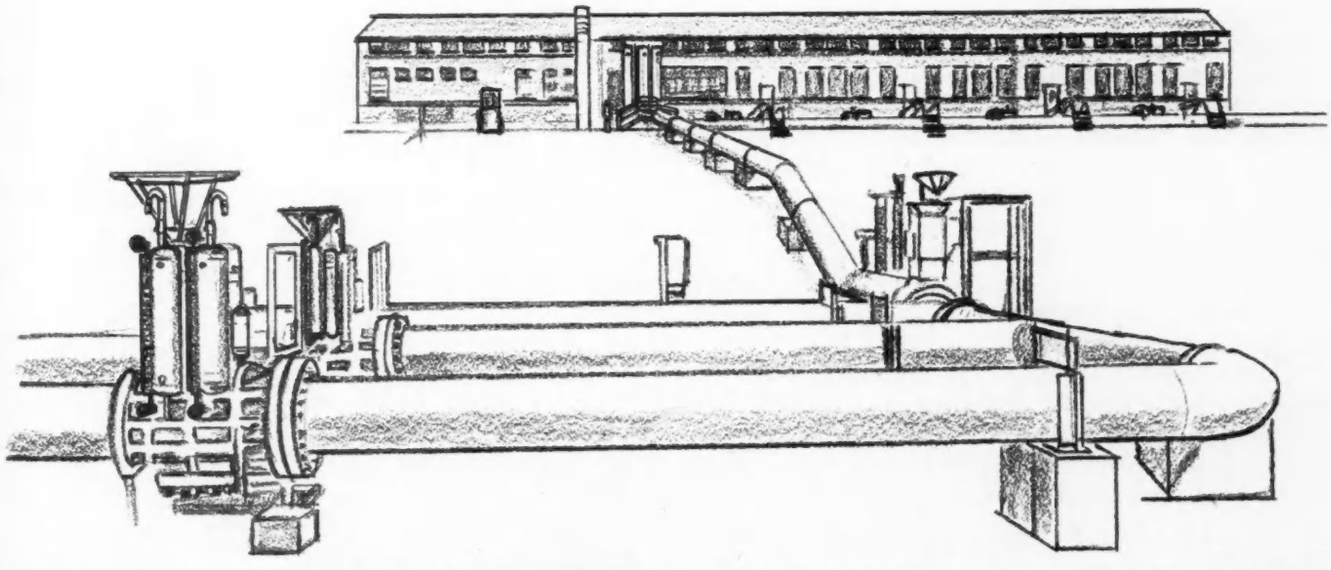


Marketed production of natural gas began to grow rapidly after 1925. The growth rate expanded sharply following World War II, as gas lines spread to all corners of the nation from big producing fields in the Southwest.

At the same time, the amount of gas vented diminished sharply. An important factor in the reduction of waste has been the higher prices received by producers. They now could afford to gather and prepare it for pipe line delivery. The increased economic value of gas also made it worth saving.

Higher prices and a realization of the extremely important function of natural gas in increasing the yield of oil have resulted in great strides in gas conservation during recent years. Widely recognized today is the principle that excessive production of gas dissipates the energy which produces oil, thereby reducing the amount of recoverable oil.

Gas flares have almost disappeared. Today, they can-



A big factor in curbing gas waste has been the construction of a network of U.S. pipe lines to all sectors of the country. Here is a modern, large volume booster station on a transcontinental gas pipe line.

not be found except in isolated areas where the gas volume is too small to be of economic value.

Gas sales rise sharply. Marketed production of natural gas in the United States did not reach 1 trillion cubic feet annually until 1923, or 99 years after it first lighted the streets of Fredonia. By 1936, marketed production reached 2 trillion cubic feet, then rose to 3 trillion by 1942, and 4 trillion cubic feet in 1946.

Use has made spectacular gains since that time, rising to more than 6 trillion cubic feet in 1950, to 8 trillion cubic feet in 1952, to 9 trillion in 1955, and to 11 trillion cubic feet annually in 1958.

ERA OF PRODUCTION WASTE AND CHAOS

The first 75 years of the petroleum industry was a period of continuing crises. There always was either too much oil or too little.

Immediately following Drake's discovery well, thousands upon thousands of people stampeded into the hills of western Pennsylvania. Everyone hoped to strike it rich. A few did. Most did not.

Whenever and wherever oil was found, the rush would be on to buy drilling sites. It was an era of "drill-and-produce as you please." The rule of capture prevailed to the fullest extent.

Rule of capture. Oil belonged to whoever brought it to the surface. Consequently, the highly fluid nature of oil led to the most wasteful practices imaginable. The more wells, the greater the production. Derricks frequently were so close together that driving a wagon between them was difficult. Wells were produced on wide open flow, or pumped as rapidly as possible if they would not flow.

Inevitably, such a torrent of oil was produced from field after field that operators did not know what to do with it, how to refine it nor how to get it to markets. Often, it went into creeks or rivers. Regardless of what became of the oil, it had to be produced so neighboring competitors would not "suck" it into their wells. Fields were depleted quickly, often within a year or two.

Such conditions were ruinous to many producers. Not a single large United States fortune can trace its beginning to the production of oil during the industry's first 50 years (the Rockefeller fortune was based on refining and marketing). Some of the Standard Oils and the Continental Oil Company are the only large oil firms of today which were in business 75 years ago. Within two years after Drake's Seneca Oil Company discovered oil, the company was bankrupt.

So much oil was found that prices fell from $20 per barrel in 1859 to as low as 10 cents per barrel during the closing months of 1861. Seneca had guaranteed the land owners a royalty of 12 cents a barrel, which made the operation unprofitable with oil selling for 10 cents a barrel.

Influence of pipe lines. The stage was set for the introduction of pipe lines to move oil from fields to refineries. Teamsters and barges were the first methods used in moving oil to refineries. By 1865, small tanks mounted on railway flatcars were in use. The first real tank cars were designed a year later.

The first crude oil pipe line is believed to have been built in 1863, but failed because of excessive leaks. In 1865, Sam Van Syckel constructed a 5-mile 2-inch pipe line from Pithole, Penn., to a loading dock on Oil Creek. This was the first successful pipe line. Pipe lines speedily became the principal means of transporting oil.

The building of pipe lines brought some stability for producers. However, there still were numerous periods of over-production. In many fields, pipe lines could not take all the oil. Consequently, producing companies owning pipe lines took the production from their own properties. The oil business still was being operated on a basis of "every man for himself."

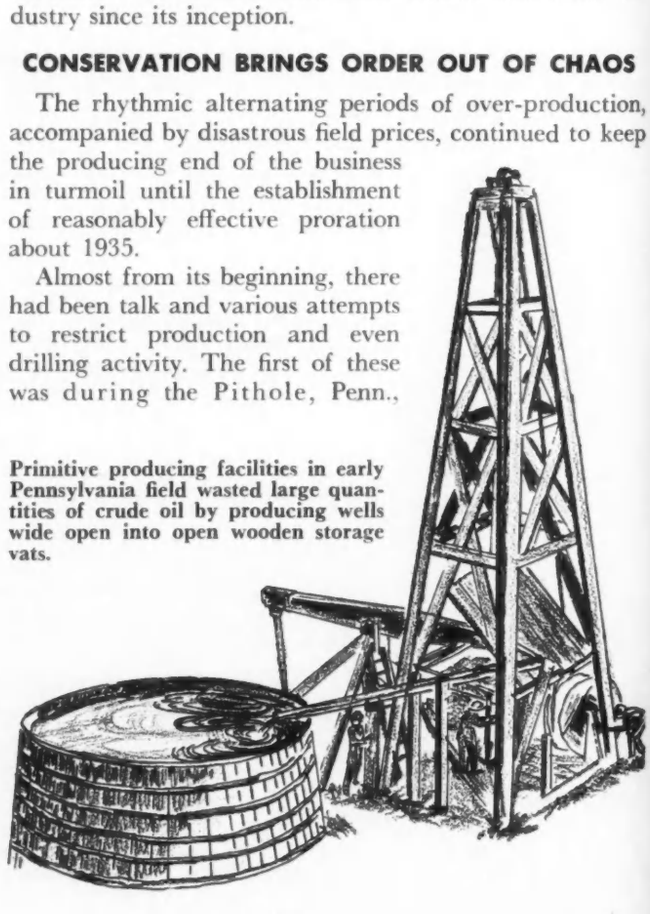
The State of Oklahoma became interested in the deplorable conditions existing at Glenn pool. This field, discovered in 1905, was to become the first field to attain a production of 100,000 barrels per day. Because of the intolerable conditions at Glenn pool, the Oklahoma legislature passed a "common purchaser" statute in 1909 which required ratable purchases within reasonable distance of a pipe line regardless of who owned the oil.

The common purchaser statute failed to bring anticipated stability and relief to discriminatory purchasing policies. However, this effort was a milestone in that it was the first attempt on the part of a state government to do something about any phase of the chaotic everyone-for-himself conditions which had characterized the industry since its inception.

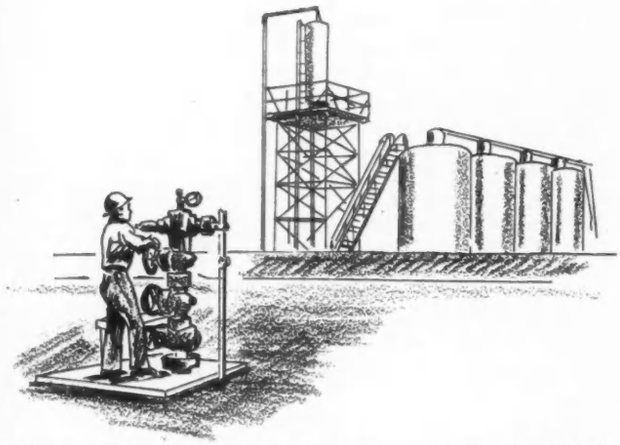
CONSERVATION BRINGS ORDER OUT OF CHAOS

The rhythmic alternating periods of over-production, accompanied by disastrous field prices, continued to keep the producing end of the business in turmoil until the establishment of reasonably effective proration about 1935.

Almost from its beginning, there had been talk and various attempts to restrict production and even drilling activity. The first of these was during the Pithole, Penn.,



Primitive producing facilities in early Pennsylvania field wasted large quantities of crude oil by producing wells wide open into open wooden storage vats.



Modern wellhead equipment provides easy means of regulating production, conserving reservoir energy and keeping wells under control at all times.

orgy of 1866, when some effort was made to restrict production. An increasing number of such attempts was made during the first quarter of the present century. Like their predecessors, these efforts called for voluntary restriction of production. At best they were makeshift, and therefore ineffectual and short-lived.

The first state order. The almost simultaneous discovery of the great Healdton and Cushing fields in Oklahoma created another great flood of oil in 1914 and 1915. The pipe line ratable purchase statute which had been passed in 1909 because of conditions at Glenn pool failed to offer the anticipated relief. Something more effective was needed.

In February, 1915, Oklahoma passed a law permitting the limitation of production to market demand. It declared production in excess of transportation or marketing facilities an economic waste, and empowered the Oklahoma Corporation Commission to limit production to the capacity of such facilities. The law went so far as to provide for the limitation of production on the basis of individual well potentials.

In 1919, a law was passed in Texas, which promulgated 38 rules to minimize oil and gas waste. This act, with later amendments, was to become the basis for the statewide conservation of oil and gas. Coming years were to see vast improvements, national in scope.

Engineering boosts conservation. Meanwhile, in most areas, each oil operator continued to drill and produce as he pleased, including, if possible, the draining of production from his neighbor's lease. As in the past, waste went hand in hand with such practices.

A few pioneer engineers prior to 1920 began to recognize the important function of natural gas in the production of oil. As the number of engineers associated with the industry multiplied rapidly during the 1920s, scientific studies increased and a new theory of petroleum production practices began to take embryonic form. These engineers soon became keenly aware of the alarming waste in production.

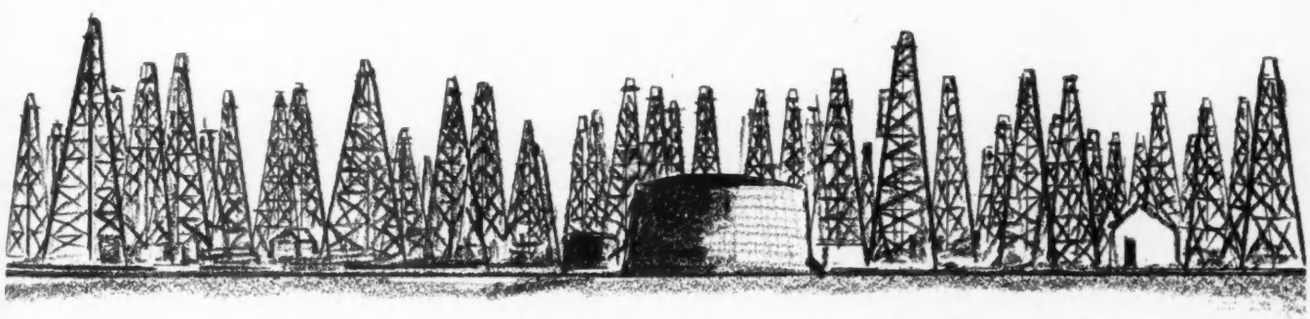
An increasing number began to urge the conservation of gas, and saw wide-open flow of oil wells as a dreadful dissipation of energy which reduced oil recoveries and shortened the life of fields. They also began to view close well spacing as both unnecessary and even harmful to efficient recoveries.

Among the industry leaders who tried to alleviate the evils of existing practices was Henry L. Doherty, president of H. L. Doherty and Company. There was much opposition to Doherty's plan, because the remedy he urged was federal government enforced unit-pool operation.

Nevertheless, the vigor with which Doherty pushed his views promoted an outburst of reservoir engineering research along with the idea of conservation. Meantime, recognition of oil's importance to the national welfare and fear U. S. oil supplies would be exhausted within a few years became a matter of such national concern that President Coolidge in December, 1924, created the Federal Oil Conservation Board. The board was to study ways to avoid waste and conserve petroleum resources, with the view of finding means of assuring the nation an adequate future supply. The board's studies were to constitute another major step toward oil and gas conservation.

Flood creates survival crisis. The middle 1920s ushered in an era of great discoveries, prompted in a large measure by the success of recently introduced geophysical prospecting methods. Such a tremendous volume of oil was found that fear of an immediate shortage of oil was dispelled. However, conditions became so chaotic, it was apparent that the producing branch of the industry could not survive.

New field after new field was discovered in Oklahoma and Texas. Meanwhile, new discoveries abroad, partic-



This 1902 scene of excessive drilling at Spindletop, Texas, not only represented a heavy financial waste, but also a physical waste of reservoir energy.

ularly in the Mexico and the Maracaibo area of Venezuela, aggravated the situation.

Conditions became so intolerable most producers advocated state regulation as a means of creating reasonable order. Early attempts at voluntary proration occurred in 1927 as the result of development of the Yates, Texas, and Seminole group of fields in Oklahoma.

In September, 1928, the Oklahoma Corporation Commission issued the first statewide proration order in history, limiting the output of eight flush fields in the Greater Seminole area. In the same year, the Texas Railroad Commission issued its first field-wide production order, limiting the output of the Hendricks field. In August, 1930, the first Texas proration order limited the production of the state to 750,000 barrels daily.

The era of regulation is born. Additional new fields continued to be found, especially in Oklahoma and Texas. They added to the mounting problems of restraining rapidly growing producing capacity to market demand, but on the favorable side demonstrated that control of production was the most effective of waste-prevention programs. Such efforts also showed producers that proration tended to keep producing operations on a more stable keel. Thus, producers came to realize regulation was their hope for survival, and state conservation authorities realized national security would be enhanced through assuring adequate future supplies.

Then, in late 1930, came the historical discovery of the East Texas field, the largest single pool found up to that time and the largest ever found in the United States. The discovery was so unexpected a large portion of the area was not leased. Oil men and would-be oil men came in droves. A wild orgy of drilling commenced immediately. Production soared. No previous boom rivaled it in size. Crude prices dropped and dropped, reaching 10 cents a barrel for a time.

It was the old days of uncontrolled drilling and production all over again. The Railroad Commission tackled the problem with determination, but legal injunctions came faster than the commission could issue new orders. Conditions worsened steadily as the field grew to enormous size.

In August, 1931, Governor Murray of Oklahoma proclaimed martial law for the booming Oklahoma City field, and 12 days later Governor Sterling placed East Texas under martial law and ordered all wells shut down.

Meanwhile, a new Texas oil conservation law had become effective on Aug. 12, 1931. Martial law gave the Railroad Commission time to issue new orders. For a time, these orders were enforced by the militia. Daily production of the East Texas field was held in check at around 400,000 barrels, although it had been above 1 million barrels daily. Crude prices rose from 10 cents to 85 cents per barrel.

Equally important was a quick response in reservoir pressure. Engineers had developed a method of taking bottomhole pressures at any desired time. The prompt favorable stabilization of the East Texas field pressure under restricted production was a positive demonstration of the benefits of slower withdrawal rates. It cannot be said that reservoir engineering was born at East Texas, but certainly it grew up there.

Conservation becomes a reality. The year 1932 was to prove a red-letter period in the history of petroleum conservation. In March, the Texas Court of Civil Appeals reversed a lower court's decision by supporting market-demand legislation as necessary to avoid physical waste. The statute had been attacked on the grounds it was a price fixing measure. In May, the U. S. Supreme Court held that the limitation of oil production to market demand was proper in order to avoid waste above and below ground, and that any effect on price was incidental.

Encouraged by these legal decisions, the Texas Legislature enacted a new oil market demand law in November, 1932. With some revisions, the state's oil production still is regulated under this act.

The era of state regulation of oil production was to become substantially effective with the passage of the Connally "Hot Oil Act" in 1935. By this act, the federal government barred oil produced in violation of state restrictions from interstate commerce.

Despite the greatest surplus producing ability then known, production thereafter was held in check. Wanton waste was stopped; conditions stabilized themselves. A new era of production practices was born.

During the days when Oklahoma City, East Texas and other large fields created some of the gravest problems ever faced by the industry, attempts had been made to correlate the growing activities of various state oil and gas regulatory agencies. Serious efforts in this direction commenced in 1931, but it was 1935 before the Interstate Oil Compact Commission became a reality. The compact was approved by Congress in August, 1935.

The Compact Commission has no authority to issue or enforce orders regulating oil and gas production. However, it has proved extremely effective in promoting better oil and gas conservation measures and in creating greater collaboration between states. By 1955, compact members totaled 30 oil and gas producing states.

The era of state regulation of oil production now was an established fact. A series of additional flush fields was to be found in coming years, but state regulation avoided the intolerable waste of the earlier days. In addition, ultimate recoveries of fields were enhanced by billions of barrels, thus making more oil and gas available at lower cost. Above all, state conservation programs created an economic stability under which technical progress could thrive.

The U. S. oil producing industry was to operate under its greatest period of stability during the next 20 years.

IMPORTS BECOME SERIOUS U. S. PROBLEM

State regulation of U. S. oil producing rates was powerless to combat the next serious oversupply threat to the U. S. oil producing industry. This threat was created by forces outside of the United States.

Extremely rapid development of production outside of the United States took place after World War II. These included the fabulous fields of the Middle East,

among which were several that outranked all previously known fields. In addition, production in Venezuela, Canada, and many other countries increased sharply.

So extensive was the development abroad that Free World proved crude reserves rose to 250 billion barrels by the end of 1958. This was five times greater than the reserves at the end of 1947. Most of the increase took place outside the United States. The United States, which had dominated the world's oil producing business for so many years now held only 12 percent of the world's total proved reserves.

United States becomes net importer. Although consumption outside the United States rose much faster than ever, surplus production became greater than ever. Since the increase was primarily in other countries, this had a double-barreled effect on U. S. oil.

Imports rose while exports fell, changing the United States from a net exporter of oil to a net importer. U. S. oil could not compete in domestic or international markets with the cheaper oils from abroad.

U. S. oil exports fell from a peak of 208 million barrels annually in 1944 to only 130 million barrels in 1954 and 1955. The decline was checked temporarily in 1956 and 1957 only because the United States was called upon to supply large emergency quantities to Western Europe when closing of the Suez Canal disrupted Middle East oil shipments.

Meanwhile, more and more oil produced in the Middle East, Venezuela and Canada absorbed an increasing portion of the U. S. market. U. S. imports rose from 138 million barrels during 1946 to 525 million barrels by 1956. They rose to 557 million barrels in 1957, despite closing of the Suez Canal, and were held to this amount only because the federal government inaugurated a voluntary restriction program on July 29, 1957.

This program was in response to the demand of independent U. S. oil producers. They feared a torrent of foreign oil from abroad would continue to supply an increasing portion of their only remaining market—the U. S. consumer.

The program was applied to crude oil only. Later, unfinished products also were restricted. Restrictions of petroleum product imports had become a serious question by the latter part of 1958, as the importation of finished products rose sufficiently to offset reductions in crude oil imports.

Early import restrictions. This was not the first time, U. S. independents had sought government aid in limiting imports of foreign oil. Back in the late 1920s and early 1930s, when state regulation of U. S. production was evolving because of large U. S. discoveries, independents sought to curb rising imports.

Conditions in the late 1920s led to the organization of the Independent Petroleum Association of America in 1929. Since its inception, the association has spearheaded the drive of independent producers to limit U. S. oil imports, although it has been joined by other groups in recent years.

A lengthy fight culminated with the passage of an oil import excise tax in 1932. The tax on oil was set at 21 cents a barrel, after several attempts to get Congress to pass higher tariff failed. With U. S. oil selling at 87 cents a barrel in 1932, the tax amounted to nearly a 25 percent excise levy. Imports immediately fell to 45 million barrels yearly in 1933 compared with 105 million barrels during 1930.

Tariff rendered impotent. Subsequent events were to reduce the effectiveness of the oil import tariff.

The first of numerous reciprocal trade agreements with other nations was inaugurated in the closing months of 1939. These agreements had the effect of halving the oil tariff, cutting it to 10½ cents per barrel in place of 21½ cents.

Meanwhile, spurred on by sharp inflation in the United States, crude oil prices in the United States rose to $3.10 per barrel by 1957. Thus, the ratio of the tariff to U. S. prices gradually fell from 25 percent in 1932 to less than 5 percent by 1947 and then to 3 percent in 1957.

The net result was that the tariff had little if any retarding influence on U. S. oil imports following World War II. This set the stage for a Presidential Cabinet Committee to declare imports were endangering national security, which, in turn, led to the establishing of the voluntary import quota system in July, 1957.

The U. S. oil import problem. The oil import problem is different from imports of other commodities because most of the oil imported is produced abroad by large U. S. oil companies.

The core of the argument by independent producers for import restrictions always has been that:

1. It was not equitable to restrict U. S. production without limiting imports also;

2. Unlimited imports would undermine the health of the domestic industry; and

3. National security would be endangered in times of war unless the United States had readily available adequate domestic supplies, and to assure the latter the domestic industry must be kept strong enough to conduct a continuous vigorous U. S. oil development program.

ABUNDANT SUPPLY AT CHEAP PRICES

Oil not only has given the world an abundant supply of heat, power, lubricants and other useful products, but it also has supplied them more cheaply than competing fuels.

Oil and natural gas supplied but one-twelfth of the U. S. heat and power requirements in 1900; just over one-third in 1935; and today furnish more than two-thirds. Consumers are free to purchase whatever fuel or source of power they desire. Any industry which can enlarge its share of the market to such an amazing extent unquestionably has served its consumers at reasonable prices.

Extremely rapid growth in the last decade presages the early domination of oil and natural gas over energy markets in other parts of the world on a similar scale.

The cheapness of oil and gas has been a major factor in their universal adoption by consumers, although coal

or electricity might perform many of the functions now performed by petroleum.

Gasoline remains cheap. The prices of all products have risen sharply during the postwar inflationary spiral since 1945. Most things cost far more today than ever. Gasoline is an exception.

Exclusive of taxes, the U. S. service station retail price of motor fuel is less today than in the early 1920s. The consumer pays more for gasoline today only because of greatly increased motor fuel taxes.

Since the automobile became a big factor in our daily lives, the price of gasoline, without taxes, has varied from as high of 29.74 cents per gallon in 1920 down to a low of 12.41 cents in 1933. The price during 1958 averaged 21.50 cents.

On the other hand, taxes on gasoline have risen from nothing in 1918 to a peak of nearly 9 cents per gallon in 1957 and 1958. Since 1950, U. S. gasoline taxes have increased 72 percent. During the same period, gasoline prices have increased only 8.5 percent.

The consumer paid an average of 30.40 cents per gallon in the United States in 1958 for gasoline, of which almost 9 cents was tax. Thus, gasoline is being taxed 40 percent of its retail price.

Even with taxes included, gasoline remains a cheap product. It still costs less per gallon than soft drinks, milk or even distilled water.

These figures show how satisfactorily oil has served the consumer with cheap products. Gasoline prices might be expected to have advanced rather sharply, being one of oil's products which has little competition from other fuels. Gasoline prices have not risen unduly because of intense competition between a large number of companies for markets, and the great technological progress that has made it possible to manufacture more gasoline from a barrel of oil. Today, about 50 percent of each barrel of crude oil is made into motor fuel. This is double the yield of 30 years ago.

Contrary to critics who view widespread state regulation of oil producing rates since 1935 as price fixing, oil has continued to provide an increasing quantity of products at cheaper prices.

Fluctuations in crude prices. Early years of the industry were characterized by violent fluctuations in crude oil prices. Each time an important new field poured forth a torrent of unchecked production, oil prices fell to such low levels that drilling became unprofitable. This created a subsequent period of scarcity, marked by high prices.

These wild fluctuations began with the birth of the industry. The average price of crude oil in 1859 was $20 per barrel, but declined to less than $10 a barrel in the following year. Then came the first overproduction crisis, causing prices to fall to an average of only 52 cents a barrel in 1861. During a part of 1861, prices actually dropped to 10 cents per barrel.

The next decade was a period of high prices. They averaged $8.15 per barrel in 1864; $6.59 in 1865; $5.60 in 1869; and $4.40 per barrel in 1871. In only one year, 1867, did prices fall below $3 a barrel.

The industry never has averaged $4 per barrel of oil since 1871, and in only three years has the price exceeded $3 a barrel.

In the 40-year period between 1878 and 1918, U. S. crude oil prices exceeded $1 per barrel during only seven years, and did not reach $2 per barrel until 1919. The national average rose to $3.07 during 1920.

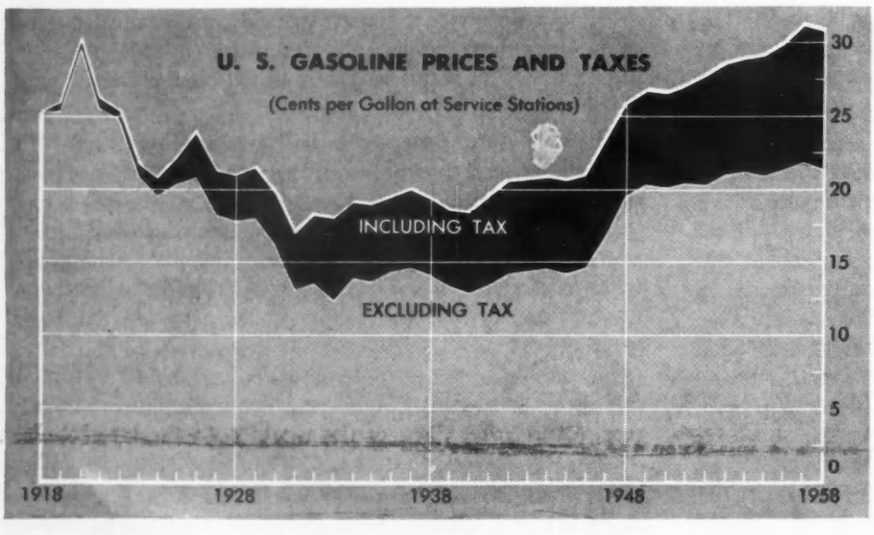
With the coming of chronic oversupply in the mid-1920s, the average price of U. S. crude tended downward to a low of $1.17 a barrel in 1928. The depression years saw prices fall to a low of 65 cents in 1931, which was the same year that East Texas and other giant fields were pouring forth another torrent of oil that threatened the industry's survival. The price in 1935 was 96 cents per barrel.

Since 1935, U. S. crude oil prices have risen slowly but steadily. They did not reach $2 per barrel until 1948. In 1957, they had risen to $3.10 per barrel, but in 1958 declined slightly to $3.07 per barrel.

It is difficult to determine whether the regulation of production has had any influence on the steady rise in U. S. crude prices since 1935. Powerful inflationary forces have been in operation since that year, particularly since 1948.

The fact that crude oil prices have not risen unduly during the inflationary period has caused the industry's operating and development costs to advance more rapidly than crude oil prices. As the oil producing industry begins its second century, it again is faced with a struggle for economic survival.

Returns from the sale of crude oil must be large enough to cover costs and leave a sufficient profit to support the industry's large expenditure rate necessitated by ever expanding markets.



FINANCIAL REQUIREMENTS ARE EXCEEDINGLY LARGE

The sharp, practically uninterrupted growth of the petroleum industry since its inception 100 years ago has imposed a heavy financial investment rate. The demands of new and expanding markets have made enlargement of facilities a continuing requirement. The peculiar depleting nature of producing operations, in which production invariably declines with age, further increases the industry's need for vast capital expenditures.

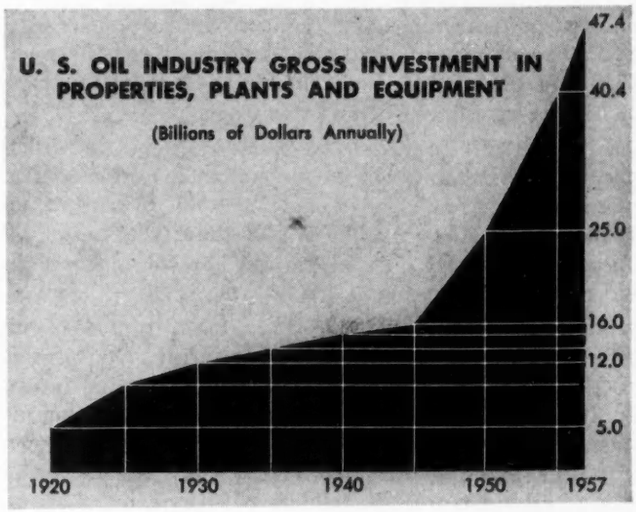
Capital expenditures at peak. Capital expenditures for property, plant and equipment of the U. S. petroleum industry have been far in excess of other industries during recent years. The rise in these expenditures has been especially sharp since World War II. A part of the increase has been due to inflation, but this has influenced the spending of all industries.

The rate of expenditure growth has been extremely large for oil because of remarkable expansion at a time of inflation. Capital expenditures in the United States by the oil industry have risen from a peak of $2 billion annually in 1946 to $6.4 billion in 1957.

The bulk of these capital expenditures has been made in the production branch of the industry. Investments for property, plant and equipment for new producing facilities—including dry holes—have increased from $1.3 billion annually in 1946 to $4.5 billion in 1957.

Capital expenditures outside of the United States also have increased rapidly in the last 10 years. Much of this investment has been made by U. S. companies. Chase Manhattan Bank has estimated that capital expenditures in the Free World outside of the United States have risen from approximately $1.0 billion annually in 1950 to $3.0 billion in 1955.

These capital expenditures reflect extensive exploration and drilling activity, both in the United States and elsewhere.



Third largest capital investment. Vast annual expenditures in recent years pushed the industry's gross investment in property, plants and equipment in the United States to $47.4 billion by the end of 1957. This was two times greater than the $23.5 billion gross investment at the end of 1949.

The gross investment in oil is exceeded by only two other U. S. industries: public utilities and agriculture.

Chase Manhattan Bank has estimated that gross investment in oil properties and equipment located in the Free World totaled $78 billion at the end of 1957.

An average rate of return. Contrary to the opinion of most Americans, earnings on the industry's investment have been no greater than other industries.

Oil's rate of return on net worth reached 10 percent in only three years between 1923 and 1945. During this same period, earnings of the manufacturing industry were 10 percent of its net worth in seven years, plus

Percent of Return On Net Investment

YEAR	Petroleum Industry	Manufacturing Industry	All Industry	YEAR	Petroleum Industry	Manufacturing Industry	All Industry
1923	6.3	10.0	7.7	1941	8.9	12.3	9.4
1924	7.4	8.9	7.3	1942	6.7	10.1	9.0
1925	10.8	10.7	9.1	1943	8.3	9.9	8.7
1926	10.6	11.0	9.3	1944	9.9	9.8	8.3
1927	5.0	8.8	8.5	1945	8.9	9.3	7.6
1928	9.4	10.7	10.1	1946	10.9	12.9	10.1
1929	9.7	12.6	10.7	1947	16.2	17.1	13.0
1930	4.3	6.3	5.7	1948	22.9	18.8	14.7
1931	—1.1	2.5	2.4	1949	13.8	13.8	11.2
1932	1.1	—0.3	0.3	1950	15.5	17.1	13.9
1933	1.5	2.7	2.6	1951	16.8	14.4	11.4
1934	2.9	4.3	3.5	1952	14.6	12.3	10.3
1935	5.2	6.6	5.0	1953	14.5	12.5	10.5
1936	7.5	10.2	7.3	1954	13.0	12.3	10.3
1937	10.0	10.6	7.2	1955	13.6	15.0	12.0
1938	4.9	5.0	3.8	1956	14.6	13.8	11.3
1939	5.4	8.4	0.0	1957	13.6	12.8	10.6
1940	6.6	10.3	7.4				

Source: Economics Department, The Atlantic Refining Company, and First National City Bank of New York.

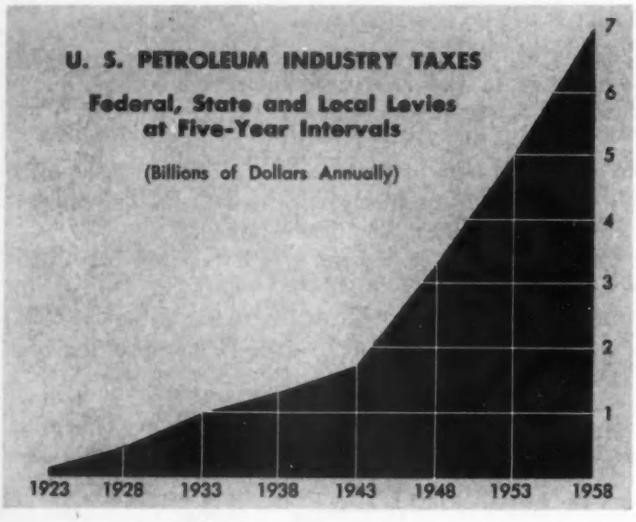
one year with earnings of 11 percent, and two years with a 12 percent rate of return on net investment. Between 1923 and 1946, all industry combined earned 10 percent of the net investment during two years.

In the 1923-46 period, oil had nine years in which it earned less than 6 percent on its net investment. The manufacturing industry earned less than 6 percent on its investment during only five of these years, and all industry combined did not earn 6 percent or more in but eight of these years.

Between 1946 and 1955, the rate of return of all industries, including oil, has risen sharply. During this 10-year period, oil has earned a smaller rate of return on its net investment than has the manufacturing industry in four years, and one year they earned the same. However, oil's rate of return has been just slightly above that of all industry during the past 10 years.

OIL PAYS BIG U. S. TAX BILL

The oil industry pays about 7 percent of all taxes in the U. S., including federal, state and local. Taxes levied on the industry and its products have more than doubled in the last decade.



The petroleum industry paid approximately $7.0 billion in taxes during 1958, compared with only $3.3 billion in 1948, less than $1.3 billion in 1937, and less than $400 million in 1927.

The magnitude of the U. S. petroleum tax bill is highlighted by the fact that in 1958 taxes almost equal the value of all the crude oil produced in the nation.

Besides income taxes, the oil industry pays numerous other levies, such as production severance taxes to state governments, taxes on all physical properties, taxes on oil under the ground in some cases, pipe line taxes, pump license taxes, inspection fees, chain-store taxes, sales taxes, fuel oil taxes, diesel fuel taxes, etc.

Of all taxes on petroleum products, the one which has produced the greatest revenue—and which is best known by the public—is the gasoline tax. State, federal and local taxes now average 8.90 cents per gallon in the nation, more in some states and less in others. The total tax collected on gasoline now is approaching the staggering sum of nearly $5 billion annually.

Taxes paid by the oil industry, in one form or another, supply about 25 percent of the total revenues of the 48 states. In many large oil producing states, oil accounts for 50 percent or more of all state taxes.

KEENEST OF COMPETITION

One of the really significant characteristics of the petroleum industry, especially in the United States, always has been an extremely high degree of competition.

The U. S. industry has more "major" companies and more smaller "independents" than can be found in other basic industries. There are 22 concerns which commonly are referred to as "majors" in the industry. Certainly, they are the 22 largest companies.

All together, there are over 45,000 corporations, partnerships, and individual operators engaged in the oil business in the U. S. Some engage in only one phase of the business, others in two or more branches. This is in addition to another 10,000 business enterprises engaged in directly related businesses, and is exclusive of more than 250,000 service stations. The vast majority of the latter is independently owned.

Many producing firms. Approximately 14,000 firms and individuals are estimated to be engaged in the production of crude oil and natural gas. The largest producing company, Standard Oil Company (New Jersey) and its affiliates, produce less than 10 percent of the U. S. crude oil.

The state regulation of production since 1935 has reduced competition between producers for a share in crude oil markets. But such regulation has not curtailed, in any way, the keen competition between producers for leases, which they must own before they can produce or drill.

The 22 largest producing companies own less than 25 percent of the wells drilled annually in the United States. In recent years, the large companies have drilled from 11,385 to 12,684 wells per year, while thousands of small companies and individuals have accounted for the drilling of 38,095 to as many as 45,734 wells per year.

Approximately 400 enterprises are engaged in the refining or manufacturing branch of the oil industry, 650 in the transportation of oil, and 20,000 in the distribution products, excluding service stations.

U. S. operators go abroad. U. S. companies own a large portion of the oil production and proved reserves outside of the United States. It is estimated that U. S. companies own almost two-thirds of proved crude reserves of the Free World, exclusive of the United States.

Large U. S. companies began to join the search for oil production in other countries after World War I. Some of them found substantial production, notably the five so-called "international" companies—Standard Oil Com-

pany (New Jersey), Gulf Oil Corporation, Socony Mobil Oil Company, Standard Oil Company of California and The Texas Company.

At the end of World War II only 28 U. S. companies were engaged in oil exploration or production activities abroad. Today, the number has increased to approximately 200.

TECHNOLOGICAL ADVANCEMENTS ENHANCE SUPPLY

Despite the rapid and tremendous gain in oil and gas consuming rates, the industry has provided mankind with an abundant supply. Periodic periods of alarm over possible exhaustion of petroleum resources always have been proven unwarranted.

The story of how the industry has supplied man with an ever-increasing quantity of oil is really a story of great technical advancement. Technological progress that comes from a healthy, competitive business has proved to be the best possible conserving and multiplying agent.

Through the years, a steady and sometimes amazing improvement has taken place in discovery, drilling, producing, and refining methods. These advances have enabled the industry to constantly find, produce and refine larger and larger quantities of minerals at cheaper and cheaper costs.

Improved prospecting techniques make possible the locating of underground structures favorable to the accumulation of oil or gas that would remain unknown if the industry still were dependent on methods in use prior to 1920. This progress has resulted in oil being produced in areas and at depths that were undreamed of at the end of World War I.

Advancements in drilling have made possible the tapping of petroleum reservoirs lying four times as far below the surface as was possible in 1920. It now is possible to drill through formations that could not be penetrated previously. Thus, huge new quantities of oil have been made available for use.

The industry now produces 60 percent or more of the oil contained in most reservoirs, double the recovery rate of 30 years ago. Fields are operated that would have been abandoned in the past because of inefficient methods then in use. Industry's engineers have discovered how to make depleted fields yield millions of barrels of additional oil.

Modern completion practices have eliminated the old, disgraceful practice of letting wells gush wildly over the top of the derrick until the hole was cleaned of drilling mud. However, this scene still was a commom sight in high-pressure fields as late as 1930.

Were it not for these advancements, the present consumption of petroleum could not be supplied.

The following five chapters briefly trace the major strides that have been made in petroleum exploration, drilling, detection, completion, and producing techniques.

OIL'S 100th Anniversary 1859-1959

CHAPTER II

Oil Discovery Techniques

TECHNOLOGICAL progress has been the greatest single factor in providing the world with an abundancy of oil despite tremendous growth in consuming rates. Among leading factors contributing to the industry's ability to meet rising requirements are significant advances in the sciences that tell where oil is likely to be found.

It is fortunate for mankind that the industry has advanced so rapidly in developing better oil finding techniques. Were it not for this great progress, the world probably would have suffered from inadequate supplies of petroleum long ago.

Tremendous growth in oil consuming rates has made necessary the discovery of enormous new volumes each year. To maintain adequate reserves for future use, more oil must be found than is produced each year. With the world now consuming 6½ billion barrels yearly, and greater amounts certain to be consumed in coming years, a terrific challenge confronts the industry's exploration branch.

Although the actual presence or absence of oil still must be determined by the drill, improved prospecting techniques and greater geological knowledge have made possible the location of favorable reservoir conditions that would remain unknown if the world still depended upon the methods in use 50 years ago. New techniques have resulted in oil being produced in areas undreamed of at the end of World War I.

Geologists' importance increaced. Geologists, geophysicists and paleontologists all have developed new advanced skills and tools of greater sensitivity and accuracy. Scientific instruments have played an outstanding role in the development of better oil finding methods. But instead of de-emphasizing the role of the geologist, they have greatly increased his importance.

The industry's geological knowledge undergoes constant change and advancement to this very day, even in regions which have been under intensive study for years. New information becomes available through numerous sources. Every well drilled, even dry holes, adds to the geological knowledge of an area. Each additional geological, geophysical or paleontological study reveals new clues, partly because of repeated interpretation of available data by different experts. As a result, new fields continue to be found in regions which have been under exploration for many years.

This outstanding technical progress has improved the industry's discovery rate, thereby reducing the number of expensive dry holes. At least 80 percent, perhaps 85 percent, of the tests drilled in unproven locations in the U. S. today are based on geological information. On the average, approximately 13 percent of this number is likely to find oil or gas production. Of the remaining 15 to 20 percent—drilled without geological advice—only 3 percent probably will be productive. An even higher percent of the wildcats drilled outside the U. S. is based on geological studies, and because of working in more virgin territory with modern techniques an even higher percent is successful.

EARLY NON-GEOLOGIC PROSPECTING THEORIES

Early-day prospecting methods were based upon experience without scientific basis. The Drake well was drilled near an oil seep along a creek bank. It soon was observed that many of the subsequent successful wells were located under similar conditions.

Consequently, early oil prospectors usually drilled near oil seeps or along creek beds. Next, it was noted that oil fields were being found along trends, and that they usually were much longer than they were wide. Consequently, the trend theory was added to that of oil seeps and creekology.

During early oil prospecting days, some persons claimed

to be possessed of a supernatural power that enabled them to determine the location of oil. These "experts" directed the driller's fate through the use of so-called divining rods or wiggle sticks, usually a forked stick, or by means of a fancy "doodlebug" gadget. The importance of these diviners reached considerable proportions in the 1860s and continued to be used to some extent even after 1900.

The notion that oil was always to be found along creeks was upset when adventurous prospectors began to drill on hilltops, and—to the surprise of many—discovered oil.

ENTRANCE OF SURFACE GEOLOGY

Although early drilling activities were not based upon scientific facts, considerable knowledge was being developed by the young industry.

The first great scientific idea developed in the search for petroleum was the anticlinal theory. Immediately after the drilling of the Drake well, pioneer geologists observed the accumulation of oil and gas in anticlines. In 1860, Professor Henry Rogers called attention to the location of many Pennsylvania wells on anticlines. The Drake well was on an anticline which Rogers had mapped some years before.

Nevertheless, the idea that geologists could perform any useful service in finding oil won little credence among oil operators. They continued to rely mainly upon creekology, seeps, hunches, and doodlebugs until after the turn of the century. Despite the big increase in the use of oil, such methods succeeded in finding enough to satisfy needs. Drilling was constantly spreading into virgin territory. There were numerous seeps and other evidences to explore. Wells were cheap, and operators could afford to drill many dry holes.

The infancy of geology. In the early 1880s, I. C. White, a geologist for the State of West Virginia, revived the anticlinal theory, and proceeded to apply his geological knowledge to the discovery of oil and gas with success. While this marked the beginning of professional petroleum geology, the industry was slow to adopt it.

The reluctance with which the industry turned to geology was due, in part, to the failure of geologists to recognize that other structural forms besides anticlines might contain oil and gas. There was a general tendency to discredit geologists because drilling repeatedly found oil in locations where the anticlinal theory did not apply.

Nevertheless, geologists continued their studies. The anticlinal theory gradually was expanded into the structural theory, embracing monoclines, synclines, domes, faulting, and combinations. This constituted marked progress, and added to the prestige of geology.

Several of the larger producing companies employed geologists during the 1890s. As the number of shallow and obvious fields were explored, it became increasingly difficult to find fields with the hit-and-miss non-geologic methods. At the turn of the century, an increasing number of geologists was being employed. By 1915, geological staffs were the rule rather than the exception.

The recently established U. S. Geological Survey published an imposing number of papers on oil geology during the early years of the 20th Century. The geological profession reached such a status that the American Association of Petroleum Geologists was organized in 1917 under the name of Southwestern Geological Society. The association has 12,000 members today.

Improved surface mapping methods. Geology made great progress as man's knowledge grew. And man's knowledge grew as more and more holes were drilled. It received additional impetus through the development of better geologic mapping methods.

The plane table, or alidade, replaced the simple level used by White in making the first petroleum geology survey in 1883. This and other advancements made it possible to determine the topographic features of large areas, and with greater detail and accuracy than before.

The first scientific approach to the finding of possible oil-bearing structures was the detailed study of changes in surface topography.

By comparing surface structures with those of productive regions, geologic knowledge grew by leaps and bounds.

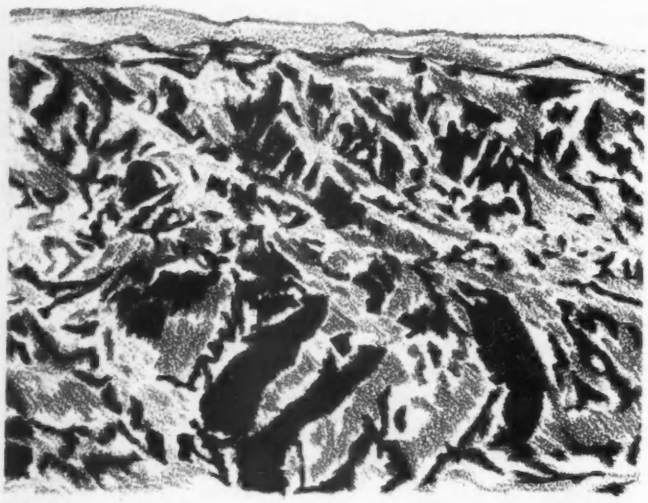
Many important fields were discovered on this basis. Thirty-seven salt domes were found in the U. S. Gulf Coast area between 1901 and 1913. Geologic studies were equally successful in other parts of the U. S. and the world. Surface geology reached its peak by 1920-21. It could be used only where rock formations were exposed on the surface, in railroad cuts, river beds, etc. Too much of the earth's surface was covered by a veneer of soil, sands, alluvium, glacial drift, shales, or the like.

The stage was set for the advent of subsurface geology. But surface geology was to continue to play an important role in the future search for oil, particularly in unexplored regions. An intensive search continued in the U. S., but geologists began an earnest search in the jungles, mountains and deserts throughout the world.

A boost from aerial photography. A great advancement in surface mapping occurred with the introduction of aerial photography following World War I. Since aerial surveys provide views of large regions, they can reveal structural features which might be missed by ground observation. They also offer a quick, inexpensive means of surveying topographic details. In addition, they

make possible the preliminary surveying of inaccessible areas.

The first use of aerial photographs for geological studies was in 1920. By 1927 air mapping was well under way in the U. S., and oil companies began to make considerable use of the airplane for this purpose.

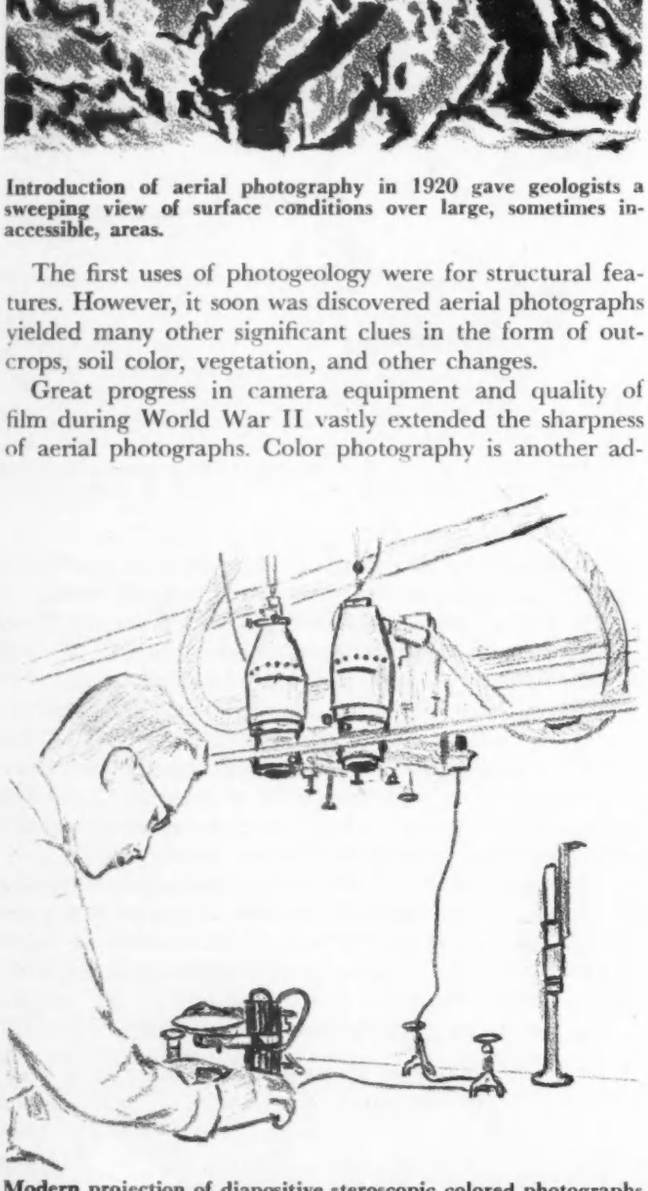


Introduction of aerial photography in 1920 gave geologists a sweeping view of surface conditions over large, sometimes inaccessible, areas.

The first uses of photogeology were for structural features. However, it soon was discovered aerial photographs yielded many other significant clues in the form of outcrops, soil color, vegetation, and other changes.

Great progress in camera equipment and quality of film during World War II vastly extended the sharpness of aerial photographs. Color photography is another advancement. Color contrasts enhance depth perception, making detail more readily perceivable. The development of various stereoscopic inspection devices also has been an important step in improving the value of aerial photography.

The mobility and versatility of the airplane and aerial camera, coupled with the incontestable accuracy of a scientifically prepared series of air maps, have contributed much to the geological progress of the industry.



Modern projection of diapositive steroscopic colored photographs shows terrain in full relief when viewed with red and green glasses making possible the orthographic plotting of contour maps.

THE ADVENT OF SUBSURFACE GEOLOGY

The need to find larger and larger quantities of oil increased manifold following World War I. The automobile and airplane were established as means of transportation, manufacturing activity was turning to mechanized methods, farming was switching from the horse to the tractor.

The more obvious surface structures had been mapped and drilled, particularly in the U. S. A new type of oil prospecting technique was needed to supply the growing needs of the world. Many, at this time, believed the U. S. oil supply would be exhausted in a few years, and it would not be much longer before the whole world would be facing an oil shortage.

Subsurface contour mapping came into its present important position with the introduction, during the 1920s, of numerous tools and methods which provided information on underground geology.

Scientists, however, knew there was a much larger area where geology remained a secret because the rock formations were covered by surface soils. They turned calculating eyes in this direction.

The need for subsurface geological data soon was to be fulfilled by a great era of unmatched scientific progress. These developments remade the science of oil discovery. They changed petroleum geology from a simple, single-phase profession to a complex, many-faceted, highly technical science.

The decade of 1920 to 1930 saw tremendous technological strides in two directions.

One was the introduction of various geophysical methods which enabled geologists and geophysicists to determine underground conditions from studies made on the earth's surface.

The second was the introduction of methods for accurately determining the character of formations encountered in drilled holes. Included in the latter methods were paleontology, core drilling, analysis of bit cuttings, coring, electric logging, and others.

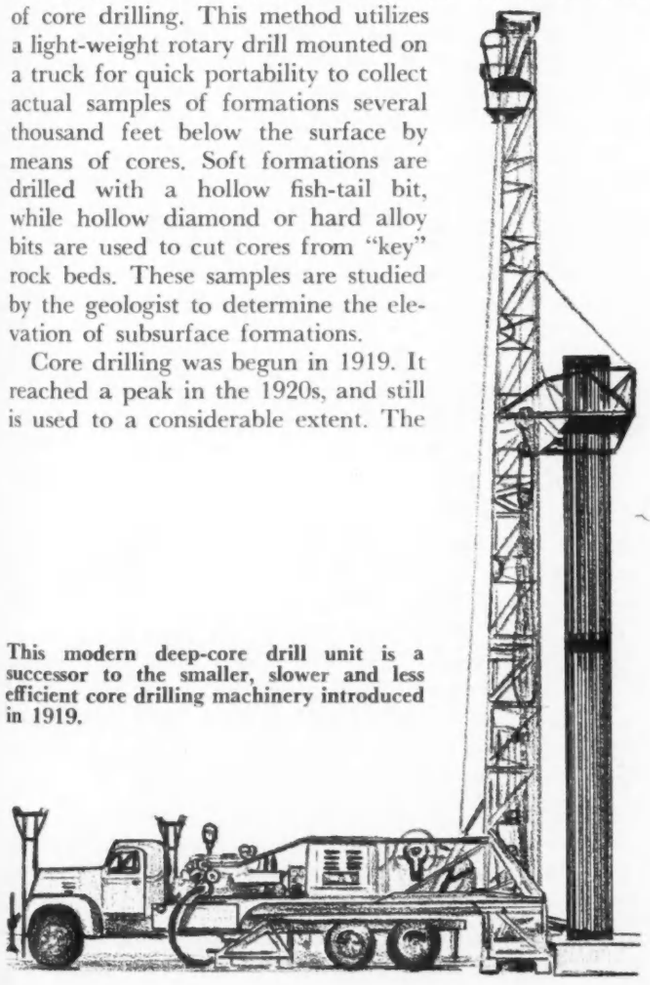
All methods needed. No one of the methods will suffice today. Each has its advantages. Therefore, each complements the others. To get as complete a picture as possible, all are needed. Consequently, all are in use today, and the modern-day geologist-geophysicist must analyze and interpret the meaning of all the records and studies.

As a result, subsurface geology remains the most prominent oil exploration means. More and more work is being done by subsurface men, and they now far outnumber surface geologists. Vast improvement in tools, means of analyzing, and in interpretations gives the modern geologist an array of extremely valuable data, much of which also are highly useful to production and drilling engineers.

CORE DRILLING FOR SUBSURFACE DATA

One of the first practical developments resulting from the need for subsurface information was the introduction of core drilling. This method utilizes a light-weight rotary drill mounted on a truck for quick portability to collect actual samples of formations several thousand feet below the surface by means of cores. Soft formations are drilled with a hollow fish-tail bit, while hollow diamond or hard alloy bits are used to cut cores from "key" rock beds. These samples are studied by the geologist to determine the elevation of subsurface formations.

Core drilling was begun in 1919. It reached a peak in the 1920s, and still is used to a considerable extent. The discovery of a number of important fields are credited to core drilling activity.



This modern deep-core drill unit is a successor to the smaller, slower and less efficient core drilling machinery introduced in 1919.

GEOLOGICAL USE OF WELL SAMPLES AND LOGS

During the hey-day of surface geology, an increasing number of geologists began conducting subsurface studies based upon information obtained from drilled wells. This type of work has increased in importance as new improved tools and techniques enlarged the amount of useful information obtained from the hole.

Microscopic examination of fossils present in bit cuttings to identify formations being penetrated has been an important geological activity since the 1920s.

Today, systematic, detailed studies and application of data revealed by drilled holes is one of the most important of all geological functions.

These activities include studies of formation cores, bit cuttings, and well logs. Means of obtaining data on which these studies are based have been perfected to a high degree. The primary objective, in most instances, was to detect the presence of oil and gas in rotary drilled holes, but they have proved to be of equal geological value.

The development of various tools and techniques used in obtaining cores, well samples and well logs are described in greater detail in the portion of this *A Century of Oil* devoted to drilling. Their value as geological tools are discussed in the following paragraphs.

Bit cuttings. As soon as geology became established, geologists began making microscopic inspections of drill cuttings for identification purposes so they could correlate depths with similar data from nearby wells, and thus prepare structural maps based on subsurface conditions.

Periodic bailing of cuttings from the hole provided the geologist with satisfactory samples in cable tool drilling. But the increasing popularity of the rotary drilling method created serious problems.

In rotary drilling, cutting samples were much smaller in grain size, were likely to be contaminated with other formations, and the time delay before cuttings were washed to the surface made it difficult to determine their depth. This made correlation extremely difficult. For a long time, rotary cutting samples were of questionable value. No longer is this true. New tools and techniques have overcome these problems.

Thanks to modern mud technology, time logs or penetration rate devices, mud logging systems, and other developments, rotary drilled cuttings are a reliable and valuable source of geological information today.

Geologists and paleontologists now can obtain an array of valuable data on the lithology of subsurface formations from drill cuttings. If desired, complete and dependable stratigraphic logs can be compiled on each well.

Cores of formations. The introduction of coring was a big geological advancement. For the first time, actual samples of subsurface formations were available in sufficient size for detailed examination.

Primitive coring tools made their appearance about 1920, and gradually have evolved into highly efficient and satisfactory units (see page 181).

The ability to obtain satisfactory cores did much to enhance paleontology by providing sufficient sizes to determine the fossil content of formations being encountered during drilling operations. This was an important adjunct in the correct identification of formations, and such studies are used extensively today.

Electric logging. One of the most significant developments in subsurface geology was the introduction in 1929 of electric logging, which mapped the thickness and sequence of various rock strata by recording the differences in electrical resistance. Well logs obtained by this method have proved so valuable from both an engineering and geological standpoint that they are virtually indispensable. Electric logs are considered so useful today that they have become routine procedure in rotary-drilled wells. In many areas, every well is electrically logged.

To the geologist, electric logs furnish effective data for subsurface lithologic correlations, for determination of strike and dip, and for location of faults. An outstanding geological advantage of electric logging is the providing of continuous recordings synchronized with accurate depth measurements.

Since the advent of electric logging, extensive and continuous research has greatly improved the instruments, thereby increasing the quantity and preciseness of formation characteristics obtainable, and enlarging the conditions under which the process can be used successfully.

Other types of well logging instruments have been developed since the introduction of the electric log. Each has its particular application. As a result, the early-day limitations of electric logging have been overcome. Excellent well logs now can be obtained in all kinds of formations and under almost any condition.

It is even possible to obtain excellent logs through several strings of casing and through cement. Thus, modern accurate logs can be obtained from old wells. Today, it is possible to distinguish between all types of formations through the use of different well logging methods.

The latest development is sound velocity logs, which promise to have wide applications. Geologically, they are providing exacting details of formation changes, and in some cases are providing data not apparent in other logs.

Acoustic velocity logs are being used to gain additional data on seismic reflections. Used in this fashion they are proving helpful in giving better interpretations of seismic surveys.

Tremendous development in well logging methods (see page 183) has opened a whole new vista to the geologist. When various logging techniques are used in conjunction with each other, the geologist is provided a wealth of data on changes in the characteristics and location of subsurface formations. These are of immeasurable value.

THE SUCCESSFUL GEOPHYSICAL AGE

In one form or another, various instruments had been used to study the physics of the earth since 1640. The science progressed rapidly during the last part of the 19th Century, and proved itself successful in locating mineral lodes.

However, geophysics was not applied to the discovery of petroleum until the early 1920s. At once, it was highly successful. Petroleum geologists now had a way to obtain information on formation conditions buried beneath the earth's surface. The use and development of the geophysics method as an oil finding device was phenomenal.

The first important event in the petroleum history of geophysics was the discovery of the Nash Dome in the Texas Gulf Coast region. The field was proved productive in March, 1924. During the next year, four additional Gulf Coast salt domes were discovered through the use of geophysical methods.

The era of geophysics had arrived. Between 1901 and 1924, surface geology found 39 salt domes in the Gulf Coast of Texas and Louisiana. But, geophysical methods were successful in the discovery of 64 salt domes in the region during the first five years following Nash Dome.

Use of geophysics soon spread to other regions. Vast improvements made the technique more and more effective. It has remained the chief means of finding favorable oil structures, and is largely responsible for the discovery of such tremendous volumes of oil that any possibility of a world petroleum shortage has been postponed far beyond today.

Gravity methods. The first geophysical instrument used in petroleum exploration was the torsion balance. It was first used as an oil prospecting device in Germany in 1920.

The torsion balance was designed originally in 1888 by Baron Roland Eotvos, University of Budapest physics professor. It measures gravity gradient changes in the earth and the direction of these changes. The torsion balance was an improved offspring of the pendulum method for measuring relative gravity.

The torsion balance was used widely in oil exploration work following the Nash Dome discovery. New and improved versions of the tool were introduced with great rapidity. Nevertheless, the torsion balance has been largely displaced by other more effective and less expensive methods of oil exploration.

The modern gravity meter came into prominence about 1935. Within a few years, it was overshadowing the torsion balance in importance as an oil exploration tool.

Present-day gravity meters are highly sensitive. Since variations in gravity are extremely small, the sensitivity

of the instruments is of utmost importance and calls for manufacturing skill and precision.

Gravity meters of today have the advantage of being readily portable by helicopter, automobile, canoe, or even by hand. Too, they permit readings to be taken quickly. Consequently, gravity meters provide means of obtaining geological studies at reasonable expense.

Great progress in the interpretation of gravity surveys has further enhanced their value as an oil discovery method.

The compactness of gravity meters has made easy their adaptation to offshore work. In shallow water, the instrument may be mounted on a simple platform above the water. Another offshore method is to lower both the gravity meter and an operator to the sea floor in a diving bell. Still another method is to lower the gravity meter to the sea floor in a pressure-tight case, using a camera to record readings.

Magnetic methods. Magnetic surveys are the oldest geophysical methods to be employed in mineral exploration. Some research on the magnetism of the earth was done as long ago as 1600, and the compass needle was used in 1640 to locate iron ore deposits in Sweden.

The magnetometer had advanced greatly by 1920, when the oil industry turned to geophysical prospecting. The magnetometer was introduced into the U. S. as an oil exploration tool in 1924, only shortly after the first torsion balance surveys.

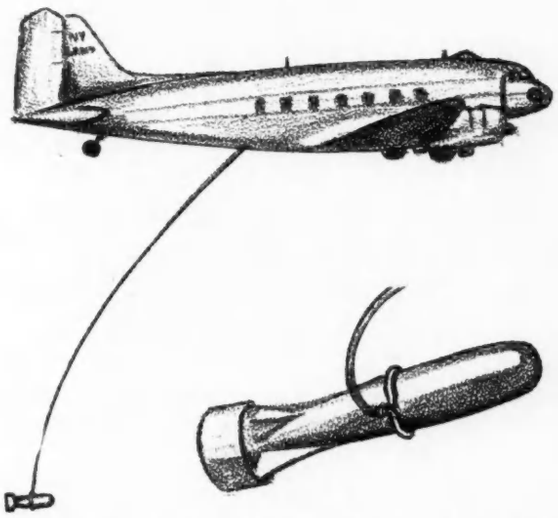
Magnetic surveys have been used widely in oil exploration. Magnetic instruments are highly portable and relatively inexpensive. However, they have had limited applications in comparison with seismic and gravity surveys.

The latest development in magnetic surveying is the airborne magnetometer. Earliest known use of the flying magnetometer dates to 1921. However, it was not successful until further improved as a submarine detector during World War II.

The first application of the airborne magnetometer to oil exploration was in 1945 in the U. S. It soon proved itself as a valuable reconnaissance tool which could cover quickly and inexpensively vast areas regardless of terrain conditions.

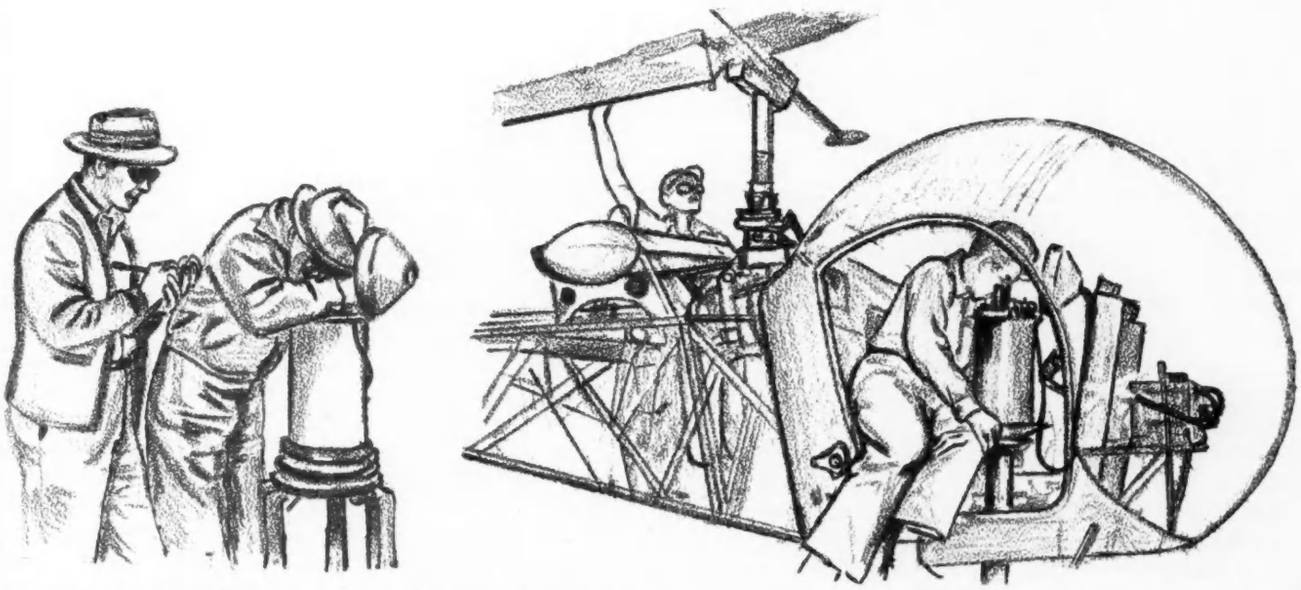
Another recent development has been a nuclear airborne magnetometer. The nuclear magnetometer readings are independent of the orientation of the detecting device.

Still another introduction of the last few years is the truck-mounted version of the airborne magnetometer. It is intended to bridge the gap between the conventional ground magnetometer and the airborne magnetometer.



Introduction of the airborne magnetometer in 1945 speeded up magnetic surveying to such an extent that large areas could be covered in a few hours.

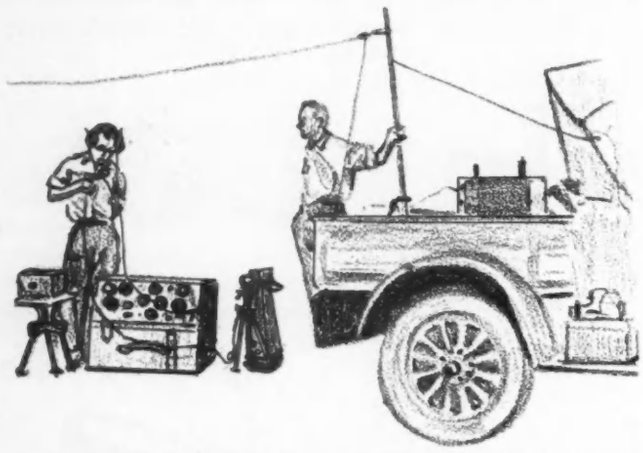
Magnetic instruments now are available in small diameter designs which can be lowered into wells. This method provides information useful in the subsurface mapping of the topography of formations.



Modern gravity meters are much more sensitive than the original units introduced in 1935. Easily transported by truck or helicopter, they give scientists reasonably priced, quick looks at large areas.

Seismic methods. The dominant method of locating structural oil traps during the past 25 years has been by seismic surveys. Seismology is by far the most important and popular geophysical technique today.

Seismic surveys trace the structural rise and fall of rock formations far beneath the surface by recording the length of time (speed) it takes shock or sound waves created by setting off an explosion to return to the surface. The first proposal for using artificially created elastic waves for studying the earth's formation was made before 1888.



A typical roadside mechanical seismograph setup in 1928 looks crude and cumbersome in contrast to modern field equipment.

A number of others proposed similar thoughts in later years.

However, the first application of the use of artificially created earth waves to the determination of local geologic structures was worked out by R. A. Fessenden, an American, in a series of experiments in 1913. Fessenden developed instruments and techniques of application, and patented his method.

Practical mechanical seismic surveying received considerable impetus during World War I, when Dr. Ludger Mintrop, a German, used it to locate enemy guns. Mintrop had been working on the study of subsurface rocks by means of artificially created shock waves since 1908, and had made considerable instrumentation progress before the war.

Mintrop succeeded in discovering a salt dome near Hannover, Germany, in 1920 with the refraction seismic method. Meanwhile, in the U. S., Eckhart, Hasemen, Karcher and McCollom made field experiments with a seismic method in Oklahoma during 1921.

During 1923, Mintrop's methods were introduced in Mexico, Oklahoma and North Texas, and, in the following years, in the Gulf Coast region of the U. S.

The first salt dome discovered in the U. S. by the refraction method was Orchard Dome, Texas. This was in June, 1924, and Orchard was proven productive in November of that year.

This caused a sensation. The method was adopted immediately by many companies, and was used in many parts of the world during the next few years. Amazing progress in instrumentation and technique occurred during the next several years. Refraction shooting found some 40 salt domes in the Gulf Coast area of the U. S. between 1924 and 1930.

The first instruments required firm foundations. Consequently, they could be used only on hard, dry ground without constructing a heavy platform. This led to the development of the electric seismograph in 1926, which used electric detectors, or geophones, to pick up the sound waves. The geophones could be lowered into any depth of mud or water. By this time, recording cameras and galvanometers also had been added to the seismograph system.

Early geophones were not nearly as sensitive as the ones in use today. Consequently, it was necessary to use large quantities of explosives. Charges ranged from 500 pounds to extreme cases of over 3,000 pounds, with the average charge approximating 800 pounds.

The need for large explosive charges was a handicap in some areas, but the chief limitation of the refraction method was the inability to penetrate the subsurface to any great depth.

Meanwhile, J. C. Karcher and associates were experimenting with the reflection seismic method, which used waves reflected directly back to the surface at high angles. The reflection seismograph was a more precise instrument, capable of mapping formation changes in great detail with remarkable accuracy. It could penetrate the subsurface to great depths, and could determine the depths of reflecting beds without plotting a profile.

The reflection method was first used commercially in Texas during 1926. Within a few years, reflection shooting had largely superseded the refraction method, although the latter still has its applications today under specific conditions.

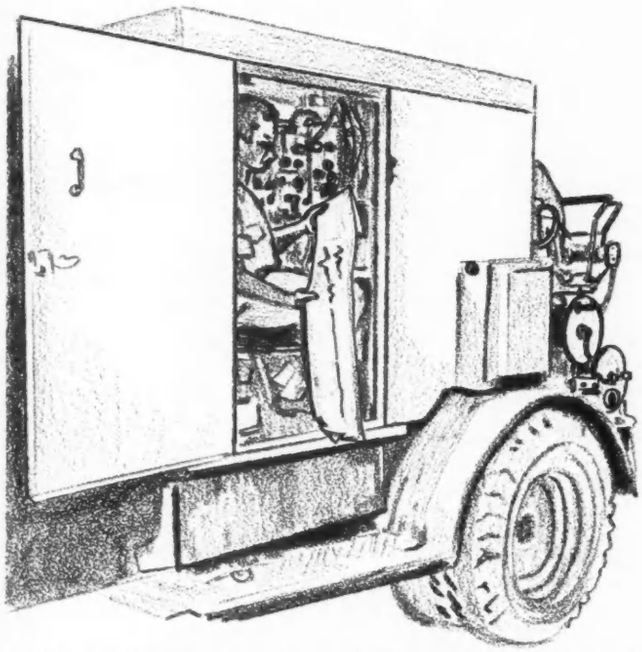
Reflection shooting is the most elaborate and most expensive of all geophysical methods. However, it has proved to be highly effective. It is credited with the discovery of more oil fields than any other geophysical method, and thereby has been worth the expense.

Rapid seismic advancement. Through continued improvement in reflection instruments and the interpretation of resulting records, reflection shooting has remained the foremost exploration technique since the early 1930s. The reflection instruments of today have little resemblance to those first used. They have been improved greatly, and now provide much more data with increased accuracy and speed.

The recent application of magnetic recording equipment and automatic computing equipment constitutes a big forward step. Work of this nature began about 1945, but has made its greatest strides in the last few years. Much more data are made available and can be processed much more rapidly.

Broad band magnetic recording has expanded tremendously the frequency range in which seismic information can be recorded. Whereas seismic work previously was confined mostly to range of 18 to 70 cycles per second, it now is possible to obtain clear recordings in frequency ranges from 2 to 500 cycles per second.

Use of high frequencies with close geophone spacing has made possible the mapping of steep dips, overthrusts and unconformities within the first few thousand feet of



Entirely truck-mounted, modern reflection seismograph is made up of highly precise instruments bearing little resemblance to the first units introduced in 1926.

the section. High frequencies also have been used to detail shale bodies.

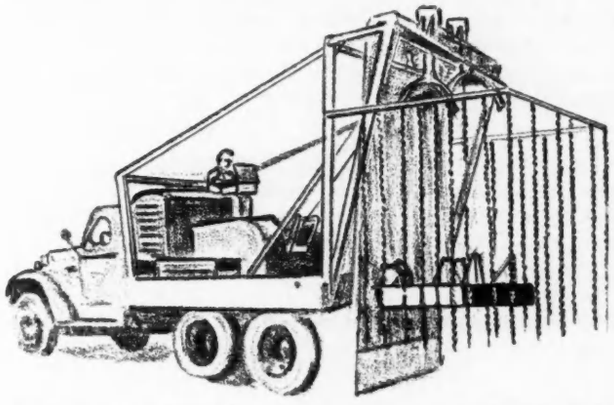
Magnetic recording also offers many other advantages. Data now can be stored in reproducible form, and "played back" repeatedly when desired. It now is possible to make multi-recordings of reflections from different depth formations, and, through the use of filters, study any desired depth reflection.

New electro-mechanical plotters transfer data—corrected for weathering, stepout, elevation, or water depths—onto cross-sections. Self calibrating voltmeters measure the energy detected by individual seismometers, thus providing a check on the effectiveness of the geophone pattern.

The extremely rapid progress of geophysics in the last five years or so presages a period of great development ahead.

Weight-dropping method. A new method of generating shock waves measured in seismic prospecting was introduced in the U.S. during 1954 after 14 years of study and experimentation. Instead of using explosives detonated in shot holes, shock waves are created by dropping a three-ton metal weight a distance of about 10 feet from a platform mounted on the rear of a truck.

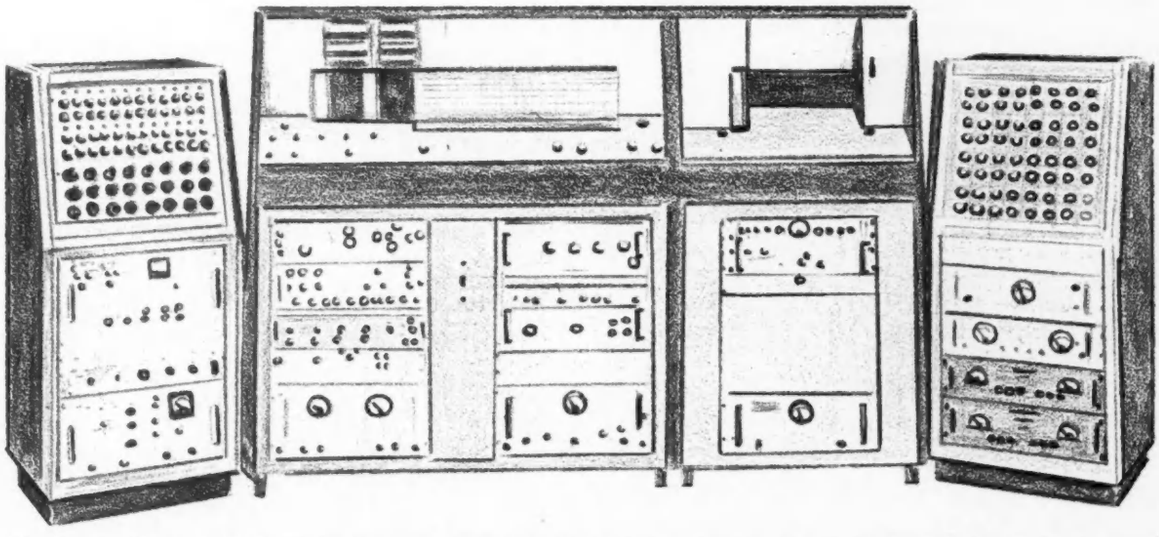
This eliminates the need for drilling shot holes, but requires the taking of a large number of recordings. The system was designed primarily for use in hard rock areas, but it has been used successfully in other regions.



The year 1954 saw the appearance of the weight-dropping method, wherein dropping of a heavy, flat weight mounted on the rear of a truck, instead of explosions, is used to generate shock waves measured in seismic prospecting.

Other prospecting methods. Other methods have been developed and tried in the search for petroleum accumulations. However, their use has been insignificant in comparison to the seismic and gravity methods.

These include a number of electrical geophysical methods; geochemical methods that analyze soil samples



The latest office playback equipment, for the preparation of time-connected cross-sections of the earth's subsurface structure from magnetic tape recordings, is one of the newest advances in seismograph work.

taken near the surface; temperature measurements based on the principle that higher temperatures will exist over structures; radioactivity surveys associated with variations in mineral content; and bacterial surveys based on knowledge that certain bacteria thrives in methane and other hydrocarbons.

HIGH EXPLORATORY ACTIVITY

With world oil consumption now totaling over 6½ billion barrels annually, or in excess of 17 million barrels daily, at least this much new oil must be found each year simply to maintain the industry's capacity to produce. Ten years ago, it was necessary to find only 3 1/3 billion barrels yearly to replace the amount produced, 20 years ago only 2 billion barrels was sufficient, while 40 years ago just half a billion barrels was enough.

As consumption grows in coming years, discovery rates must become even greater. This imposes a tremendous discovery challenge.

Consequently, the industry of necessity must constantly expand its discovery efforts. No records are available on the thousands of hours of work by geologists. However, the 12,000 membership of the American Association of Petroleum Geologists is illustrative of the extent of the geological effort.

Increased geophysical activity. The need to find huge quantities of oil has resulted in geophysical activity being boosted to very high levels. During the years 1955-1956-1957, an average of slightly more than 1,100 geophysical crews of all types was employed in the search for petroleum in the Free World. There were more than 13,000 crew-months of petroleum geophysical exploration during these years.

More than half of the geophysical activity of the world is in the U. S., although its portion has declined somewhat in recent years. Geophysical activity spans the globe.

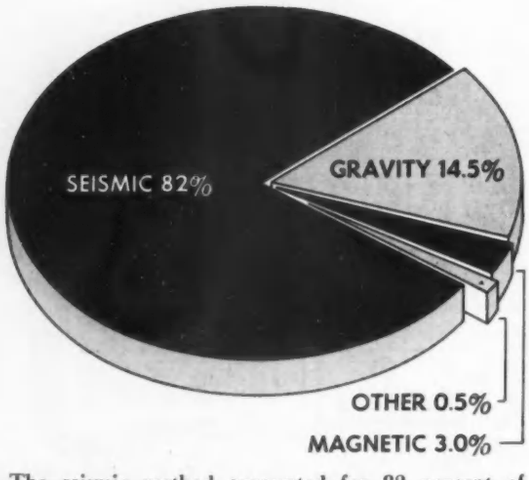
The seismic method accounts for most of the Free World's geophysical activity. Of the 13,467 crew-months devoted to petroleum geophysical prospecting during 1957, the seismic method constituted 82 percent, or 11,062 crew-months.

A breakdown of Free World geophysical activity by areas and methods for the year 1957 is shown in the following table.

Free World Geophysical Activity by the Petroleum Industry During 1957
(Figures in Crew-Months)

	Seismic	Gravity	Magnetic	Other	Total
United States	6,283	879	80	..	7,242
Canada	1,308	80	...	..	1,388
Mexico, Central America and West Indies	277	72	6	..	355
Europe	1,331	102	137	22	1,592
Africa	525	292	58	16	891
Middle East	262	118	45	3	428
Far East	388	176	24	10	598
South America	688	235	50	..	973
Total	11,062	1,954	400	51	13,467

DISTRIBUTION OF FREE WORLD GEOPHYSICAL ACTIVITY BY METHODS in 1957



The seismic method accounted for 82 percent of the 13,467 crew-months devoted to petroleum geophysical prospecting in the Free World during 1957.

FREE WORLD GEOPHYSICAL WORK PERFORMED BY CONTRACTORS DURING 1957

Geophysical contracting firms conducted two-thirds of the crew-months devoted to petroleum prospecting in the Free World during 1957.

Figures on crew-months of geophysical activity are exclusive of aeromagnetic work. During 1957, airborne magnetometer activity amounted to more than 400,000 lines-miles, according to incomplete data.

Role of contractor. Contracting or service companies are hired by producing companies to conduct most geophysical operations. These specialists have developed into an important segment of the industry.

Contractors performed two-thirds of the geophysical crew-months devoted to petroleum prospecting in the Free World during 1957. Contractors did an even higher percent of the geophysical work in the U. S.

Most U. S. wildcats are dry. Wildcatting activity is a tremendously expensive activity for oil companies and operators. The vast majority of all wildcat tests are dry holes. They will not earn one penny of income for their owners.

A few fortunate independent operators who find production may reap great wealth from oil. But, for each of these, there are thousands of unheard of investors who will lose their bankrolls.

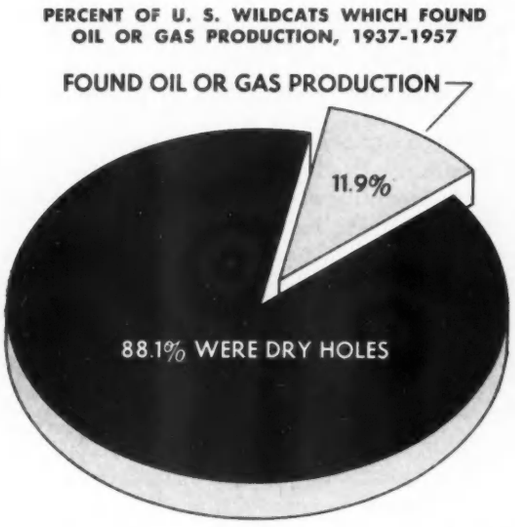
Even in this modern day of highly scientific oil pros-

pecting, only one of every nine wildcats drilled finds oil or gas production.

During 1937-1957, less than 12 percent of all wildcats drilled in the U. S. found production. Many of these did not discover enough to pay off their investors. Only one out of 44, higher odds than on the gambling table, discovered a reasonably large size oil field.

The general public knows the oil industry for the few men the business has made extremely wealthy. In these days of high costs, the number of men becoming rich from oil is dwindling fast.

Total expenditures by oil companies for geophysical activity in the U. S. ranges in the neighborhood of $500 million annually. Large sums also are spent yearly for the multitude of additional studies and services used in modern-day oil prospecting.



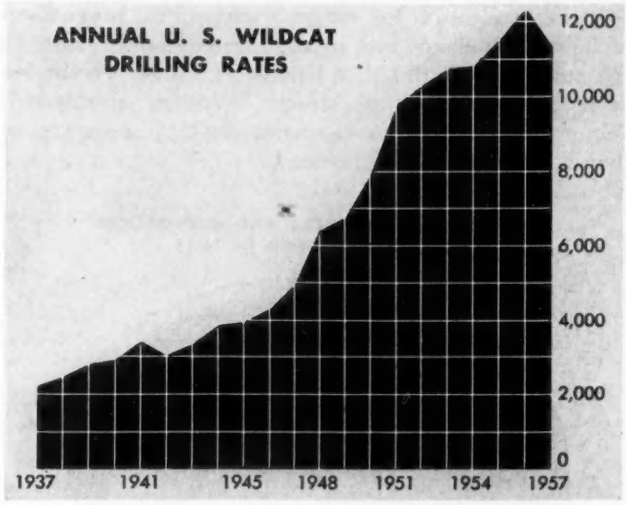
Less than 12 percent of all wildcat tests in the United States during the 1937-1957 period succeeded in finding oil and gas production.

Wildcatting reaches high rate. Growing demand for petroleum has made necessary the industry's steady increase in the number of wells drilled in search of new producing sources in unproven locations. These tests are called wildcats, to distinguish them from development wells in proven areas and exploratory wells in semi-proven areas. The rate of expansion has attained very high levels in recent years.

Despite tremendous strides in prospecting techniques, there still is only one way to prove whether oil and gas actually exists. This is to drill a test well.

Wildcat drilling activity in the U. S. has doubled in the past 10 years, and in recent years has been six times greater than 20 years ago. From 11,000 to more than 12,000 wildcat tests have been drilled annually during the 1955-1956-1957 period.

Wildcat drilling has increased faster than the industry's total drilling rate during the past 20 years. Whereas only 6.7 percent of the wells drilled in search of oil or gas production were wildcats in 1937, wildcats have made up more than 20 percent of all U. S. drilling since 1951.



U.S. wildcat drilling activity in recent years has been six times greater than 20 years ago and has doubled in the past 10 years.

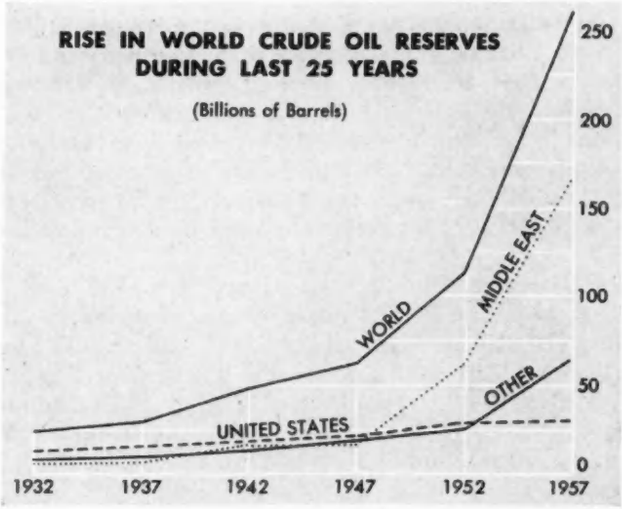
NO SHORTAGE OF OIL IN SIGHT

Despite skyrocketing growth in consuming rates, the world has had an abundant supply of petroleum at all times. This has been due to technological progress in all phases of the industry, coupled with increased exploratory and drilling activity.

Discovered, unproduced reserves of oil today are at a historic peak. Discovery rates each year exceed the quantity produced, adding further to known reserves.

Record unproduced reserves, combined with the recent exceptionally high rate of new field discoveries, provide assurance that the world will have ample oil supplies for some years to come.

Present unproduced known reserves are estimated at 260 billion barrels. This is more than double that of five years ago, and nearly 4½ times greater than 10 years ago.



The world's proved unproduced crude oil reserves have risen sharply during the past decade, primarily because of unusually large discoveries in the Middle East—which now holds more than half of all known reserves.

In all, a total of 362 billion barrels of oil is estimated to have been discovered in the industry's 100 years. Of this amount, only 10 billion barrels, or but 28 percent, has been produced and consumed. Therefore, the world's known unproduced reserves today are 2½ times greater than all the oil produced to date.

QUANTITY OF PRODUCED AND UNPRODUCED OIL IN THE WORLD IN 1958

Seventy-two percent of the 362 billion barrels estimated to have been discovered in the world since the industry's birth 100 years ago remained unproduced in underground formations at the beginning of 1958.

Shift in reserve sites. Recent years have seen a significant shift in the location of proven unproduced reserves.

Twenty-five years ago, the U. S. held half of the world's reserves. Today, less than 12 percent of the reserves are in the U. S.

This change is due to the rapid development of oil resources outside the U. S. This development has been especially swift since World War II, particularly in the Middle East.

Ten years ago, the world's crude reserves were about equally divided between the U. S., the Middle East and the rest of the world. Today, one-eighth of the reserves are in the U. S., nearly two-thirds in the Middle East, and one-fourth in the rest of the world.

This shift in world reserves has taken place although the last 10 years have seen U. S. reserves rise by 50 percent. Meanwhile, Middle East reserves were advancing by 800 percent, and those in the rest of the world by 300 percent.

The high concentration of world reserves in the Middle East indicates this area will produce an increasing portion of the world's oil in the future.

MODERN GEOLOGIC STUDIES

All the large variety of proven exploration tools and techniques are used today. Current practice is to coordinate the vast quantity of information available from the multitude of different sources.

Consequently, the modern art of oil discovery is a complex endeavor. It involves a wide variety of surface studies, subsurface studies, stratigraphy, paleontology and geophysics, each of which includes numerous highly scientific phases.

OIL'S 100th Anniversary 1859-1959

CHAPTER III

Drilling Practices

GREAT progress in drilling methods and equipment has unfolded during the first hundred years of oil. Numerous major advancements in hole-making techniques, machinery and tools have made possible the reaching of ever-increasing depths at constantly faster speeds, as well as the overcoming of such obstacles as high-pressures, sloughing intervals, and exceedingly hard zones that previously caused hole abandonment.

Most progress has occurred since the mid-1920s. That is not surprising since this period marked the real entrance of steel and engineering into the oil industry.

By providing the means of reaching oil at greater depths and under conditions previously impossible, these developments have been a major factor in the industry's ability to discover and produce enough oil to meet rapidly growing consumption and, at the same time, build up a huge volume of proved, unproduced reserves for future use.

Oil found at deeper depths. Since Colonel Drake drilled the world's first producing oil well in 1859, wells have been drilled progressively deeper. This has made huge additional quantities of oil available. Much of the world's production today comes from depths which could not be reached without modern improved drilling techniques and machinery.

The greatest achievements in deep drilling have occurred in the last 25 or 30 years, since engineering became a major factor in the industry's operations. It was 72 years after Drake's well before the first test reached 10,000 feet. In the 28 years since that event in 1931, drilling depth records have increased rapidly. The first 15,000-foot test was drilled in 1938, the first 20,000-foot hole in 1949, and the first 25,000-foot test in 1958.

This rapid growth in penetration depths is highly significant. It means 2½ times more feet of the earth's subsurface may be tested today than in 1931. In recent years, drilling to 10,000-15,000 feet has become common, and large quantities of oil are produced from these depths. In countless instances, deeper drilling has found prolific production on structures which had been tested repeatedly at shallower depths without success.

It is noteworthy that approximately 5,000 feet of additional formation has been placed within reach of the drilling bit each decade since drilling of the first 10,000-foot hole in 1931. The remarkable regularity with which deep holes are drilled today is possible only because of the great strides made in both methods and tools.

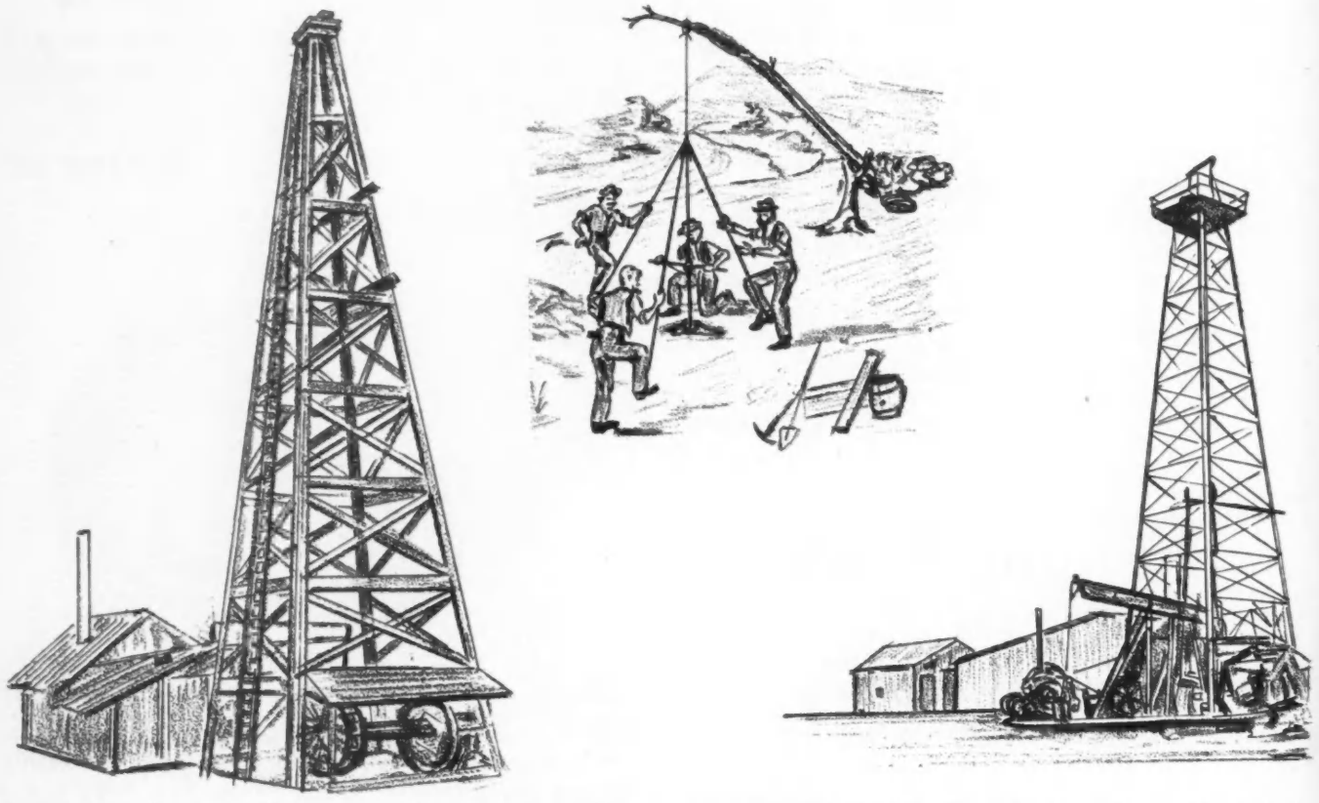
More wells at higher costs. The need to produce more and more oil to satisfy rapidly growing consumption has made necessary the industry's drilling of an increasing number of wells.

This has come to constitute a major financial burden. Drilling costs have risen faster than the number of wells drilled. Costs multiply rapidly with depth. Higher costs of labor and materials as a result of monetary inflation in recent years have made substantial additional boosts in drilling costs. Estimated total expenditures for drilling operations in the United States have risen from $1½ billion annually in 1948 to more than $3 billion per year since 1955.

Prior to World War II, the U. S. drilling record was 35,213 wells and 105.1 million feet of hole in a single year. During 1954-1957 inclusive, more than 50,000 wells and 200 million feet of hole have been drilled annually in the United States. The peak was 58,418 wells and 235.4 million feet of hole in 1956.

Drilling activity also has risen sharply outside of the United States since World War II. During 1957, nearly 9,000 wells and 44 million feet of hole were drilled in the Free World, exclusive of the U. S. In 1953 less than 6,500 wells and 26 million feet of hole were drilled.

It is extremely doubtful if the industry would be finan-



Many early wells were drilled by manually powered, primitive spring pole rigs, illustrated at top center. Ten years after Drake's discovery well, cable tool rigs, like the one at left, were the common means of drilling. In contrast, modern cable tool rigs, shown at right, are of all steel construction.

cially able to drill such a large number of wells if improved technology had not exerted major forces that tend to hold drilling costs down.

Faster penetration rates. Because of improved drilling methods and equipment, footage is made with such rapidity today less time is required to drill a 10,000-foot test than was needed for a 5,000-foot test a relatively short time ago.

Even in hard rock areas, it is not unusual to drill 10,000 feet in 30 to 45 days. In soft formation regions, as much as 14,000 feet has been drilled in 14 days on rare occasions, which is about as fast as the crew can make additions to the drilling string.

Increased penetration rates have been a major factor in holding down drilling costs. The ability to make hole faster has led to the drilling of more wells and more footage with fewer rigs. An average of 4,950 rigs was operated monthly in 1948 to drill 39,477 wells and 136.7 million feet in the United States. But 1958 fewer rigs drilled 14,223 more wells and 92.7 million more feet of hole in 1957.

The reduction in number of rigs operated has created highly intense competition among drilling contractors, who account for about 93 percent of all U. S. drilling. Competition has forced contract prices steadily downward. In the face of major advances in equipment and labor costs, drilling contractors have been able to survive only because of increased penetration rates keeping drilling costs down.

The average contract price per foot was only $4.60 in 1957 compared with $5.85 in 1952, according to the American Association of Oilwell Drilling Contractors. Even this reduction has not been sufficient to reduce total drilling costs. Including materials and services provided by operators, total drilling costs climbed to an all-time high of $14 a foot in 1957, in contrast with $12 a foot in 1952.

Only a strong, healthy industry can finance such heavy expenditures. By helping to keep drilling costs down and, at the same time, helping to make large additions to crude oil supplies, drilling technology progress has been an outstanding factor in providing an abundance of oil at reasonable prices.

EARLY DRILLING OPERATIONS

Drilling history dates far beyond Drake's famous oil well. The exact place and time of the first drilling operation is unknown. History records that Chinese drilled for water and brine 2,000 years ago, and encountered petroleum as early as 1618.

The Chinese method, with slight variations, was adopted in other parts of the world at early dates. So far as known, David and Joseph Ruffner drilled the first well in the U. S. in search of brine near Charleston, W. Va. Started in 1806, it was completed in 1808 at 58 feet.

The primary method in the 1850s was to suspend an iron bit by means of a grass rope from a spring pole mounted on an upright forked stick and fastened to the ground at one end. Two or three men provided the neces-

sary up-and-down churning movement for the bit by intermittently suspending their weight on stirrups attached to the raised end of the spring pole.

By the time Drake and his associates decided to drill for oil at Titusville, drilling methods had improved considerably. Jars had been invented by William Morris in 1831 to impart a sharp jar to the bit. A few of the more well-to-do water and salt brine contractors were using steam engines for power instead of men, and were utilizing short wooden derricks to increase the penetration of the bit by getting a longer, harder drop. Wooden casing also had come into use.

Drilling Drake's well. After the entrance of water from nearby Oil Creek ruined his attempt to complete a hand-dug well at Titusville, Drake decided drilling was the more economical and better procedure. Instead of the man-powered spring pole, Drake selected the then modern steam engine method. He erected a 35-foot wooden derrick equipped with a walking beam and heavy flywheel to lift the drilling tools. As a prime mover he used a one-flue 10-horsepower wood-burning boiler that delivered its steam directly into a six-horsepower engine.

The hole was pounded out with a chisel-shaped bit about 30 inches long, with a 1½-inch cutting edge. After drilling for a while with the small bit, the hole was reamed out by using a heavier bit with wider cutting edge. The bits, weighing between 100 and 200 pounds, were made of iron and had a heavy threaded rope socket connection at the upper end. Pulverized material was removed from the bottom of the hole by means of a crude sand pump.

Drilling was started in June, 1859, and oil was encountered on August 27 of that year at 69½ feet. Thus was born the great petroleum industry that was to drill nearly 1.8 million wells in the United States during the next 100 years.

IMPROVEMENTS IN CABLE TOOL METHODS

Completion of the Drake well started a great deal of activity in Pennsylvania, which soon spread to other states. Thousands began drilling for oil. If they did not have the price of boilers and engines, they drilled with the old manually operated spring-pole rig.

Within a short time after Drake's well, equipment showed considerable improvement. Boilers increased from 10 and 15 horsepower to 25 and 40 horsepower. Steam engines likewise increased in horsepower, were separated from the boiler by use of belt drives and could be reversed.

Drilling tools were made heavier, weighing 2,000 and 3,000 pounds. Manila rope took the place of grass lines. Within a few years, the old spring-pole method of salt-well days was replaced entirely by steam-driven rigs. Wells were being drilled below 2,000 feet by 1875.

By 1900, many changes had taken place in the percussion system of drilling, more commonly called the standard, or cable-tool, method. Mass produced steel came on the market in the 1860s, marking the start in improved metallurgy of oil field tools and equipment. As holes went deeper, drilling tools were made heavier and longer (up to 60 feet), and an increasing number were made of steel instead of iron.

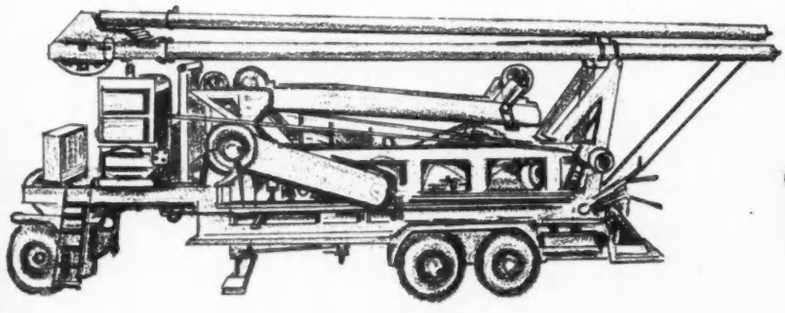
The first wooden derricks to be put together with bolts instead of nails were built in 1899. They soon became popular. Steel derricks had been introduced in the early 1890s, but wooden derricks remained popular for many years. The first chain drive was introduced in 1899.

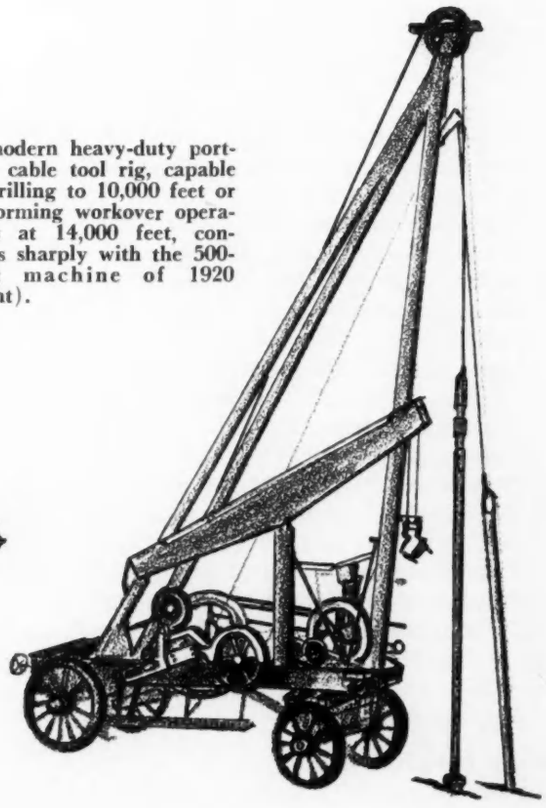
Multiple boilers were being used by 1900, wire lines were adopted, and other tools were improved and enlarged. Improvements in the drill stem, drilling jar, bailer, and other tools also helped make drilling faster and easier. Steel casing was replacing iron and wood pipe.

These advancements permitted the drilling of a test near Pittsburgh, Penn., to a depth of 5,575 feet in 1898.

By the mid-1860s, portable cable tool drilling machines had been introduced, the forerunner of modern spudders that still are in use in shallow areas.

The standard, or cable tool, method has been replaced by the rotary system as the principal drilling method.





A modern heavy-duty portable cable tool rig, capable of drilling to 10,000 feet or performing workover operations at 14,000 feet, contrasts sharply with the 500-foot machine of 1920 (right).

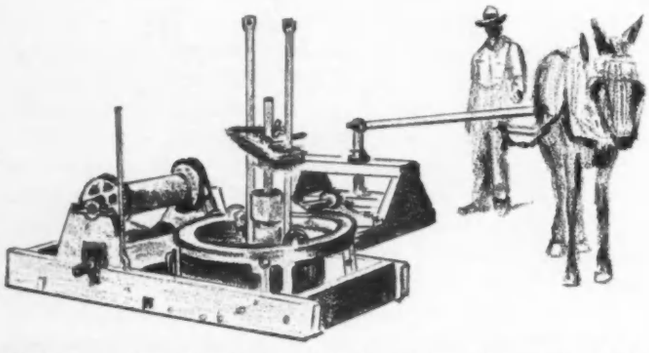
However, cable tools are being used today in many areas, particularly in the very shallow regions of the U. S.

Through improved technology and metallurgy, the modern cable tool rig is capable of drilling below 10,000 feet. Wood and iron have been replaced by high-grade steel in making nearly every piece of equipment from the derrick, through the cable to the bit. Up to 200 feet of hole a day can be made, depending on the types of formations encountered. Colonel Drake was lucky to make three feet a day.

ROTARY METHOD REVOLUTIONIZES DRILLING

An extremely significant advancement was the advent of the rotary drilling method. It was to revolutionize drilling practices, making possible the fast, deep penetration records of today.

In the short span of 60 years, rotary drilling has grown by leaps and bounds. From a small operation, where most of the work was done by muscle and lever, rigs have grown to heavy, powerful, automatically operated machinery capable of drilling to more than 20,000 feet.



Mules sometimes furnished power for the earliest, most primitive form of rotary rig, although this form of drilling was not used by the oil industry until just before 1900.

Today's largest steel derricks rise 200 feet in height, almost three times taller than the small wooden derricks used at the turn of the century.

The power on heavy-duty rigs now reaches upward of 2,000 horsepower, almost 100 times that of the tiny engines on early rigs. Internal combustion engines have replaced the steam rigs, and diesel-electric rigs also are in use.

Open chains, knee-operated clutches, and bull wheels for drilling lines have been replaced by the all-enclosed unitized drawworks with remote operated clutches and variable speeds.

Output of high-pressure high-volume pumps now used to circulate drilling mud is many times that of earlier types.

Almost every item on a drilling rig today reflects great improvement. Drilling speeds and weights are automatically controlled, instead of being operated manually by the driller. Power tools, in many instances, have taken over the strenuous manual task of breaking-out and making-up the drill pipe.

Early rotaries. The rotary drilling system, in which a bit on the end of a string of pipe is rotated in augur fashion while a circulating fluid washes the cuttings out of the hole, had been used by U. S. water well contractors since the 1880s. They found it superior in some areas to the cable tool system. Mules provided the motivating force for some of the early "poor boy" rotary rigs, but steam was the principal source of power.

These early rotaries reportedly were modifications of a water-flush system designed by a French engineer named Fauville, and first used in France in 1846.

M. C. and C. E. Baker introduced the rotary system to the oil industry when they encountered oil while drilling water wells at Corsicana, Texas, in 1895. The Corsicana field, the first commercial production in Texas, was developed with the rotary system.

While at Corsicana, the Baker brothers, with the aid of Elmer Atkins, H. G. Johnston, and Charles Rittersbacker, developed a more efficient type of rotary. It was the predecessor of the type now so well known and widely used.

Lucas makes rotaries famous. While the practicability of drilling oil wells with rotary rigs was demonstrated at Corsicana, the method did not receive wide recognition until Capt. Anthony F. Lucas used it in drilling his famous Spindletop, Texas, discovery well.

This well, which rightfully and often is referred to as the birth of the modern oil industry, was America's first great gusher. It flowed an estimated 35,000 to 100,000 barrels daily over the countryside after reaching 1,160 feet on Jan. 10, 1901.

The huge spectacular flow of the well created great fanfare. It was a vital force in moving the center of oil operations to the Southwest and Mid-Continent regions. The then little known rotary drilling system came to attention of the industry through the interest focused on the Lucas gusher.

Spindletop wells were drilled in far less time then it previously had been thought possible. Within a year, 150 wells had been drilled.

Methods and equipment used in drilling Spindletop, though improved over earlier models, still were crude compared with today's highly efficient rotary drilling system. Rotaries of around 1900 consisted of a 6 x 8, two-post drawworks weighing 5,000 pounds, a 9 x 12 steam engine, a 30-horsepower boiler, an 8 x 5 x 10-inch slush pump weighing 2,000 pounds, and a rotary table weighing about 1,800 pounds. Traveling blocks weighed around 300 pounds, and 16-inch sheaves were used. A malleable chain from the drawworks to the rotary rotated the drill pipe. All pipe was screwed and unscrewed slowly and tediously by hand chain tongs.

Spread of rotary drilling. From Spindletop, the use of the rotary system spread rapidly. No other system was used in the Gulf Coast region. By 1905 or 1906, the rotary was being used extensively in the Santa Maria district of California, and other parts of the world.

Early-day rotary rigs had many drawworks and were limited by their inability to cope with certain problems. Improvements came in rapid succession with wider use. With better design and materials, more efficient use of power and increased size, the introduction of rock bits,

and other advances, the rotary was in common use in the early 1920s in Texas, New Mexico, Oklahoma, California and fields outside the United States. However, it still was a long ways from the efficient tool it has become during the last 25 years.

Continuous refinements in materials and methods have increased the capabilities of the rotary system until it is the most efficient hole-making device known. Consequently, the rotary system has grown in popularity to such an extent it has been utilized on over 85 percent of the wells drilled in the United States during recent years.

EQUIPMENT STANDARDIZATION A BIG STEP

Both drilling and producing operations were handicapped seriously by the extremely wide variation in the sizes, threads, weights, and other features of early-day oil field equipment. Each manufacturer designed his tools according to his own ideas or those of his customers. Manufacturers of specialty tools had to make them in a wide variety of patterns and sizes so they could be used in conjunction with other component parts. This led to high manufacturing costs and great waste in the field.

One of the most significant of all advancements of the petroleum industry has been the development of an effective oil field equipment standardization program. The first step in this direction was during 1919, when the general secretary of the newly-formed American Petroleum Institute met with representatives of three manufacturers to discuss the deplorable situation.

After several additional meetings, the Institute's board of directors in 1923 appointed several committees to develop recommendations on the standardization of such items as pipe threads, rig irons, cable tool joints, wire line, belting, rigs and derricks. In 1924, authorization was given for the creation of a Division of Standardization of the API to administer the work of equipment standardization. This has continued to be a most important function of the API. Manufacurers and users of equipment have participated jointly in the development of these standards.

The program has led to adoption of simplified standard sizes, interchangeability of equipment, common threads, establishment of proper minimum and maximum specifications to insure adequate quality and strength, and to testing procedures.

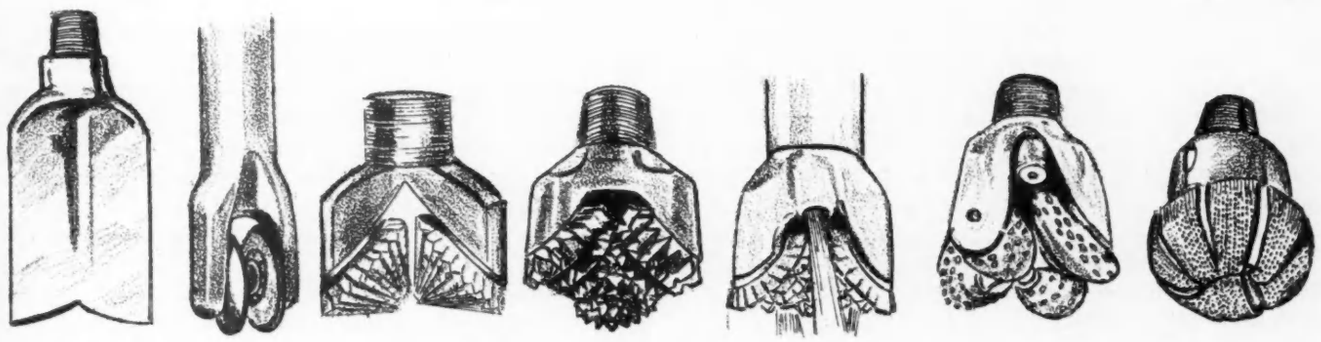
Since its inception, standardization of equipment has saved countless millions of dollars in drilling equipment and time.

CHISELS TO JET BITS

Many types of drilling bits have been tried since the introduction of the rotary drilling system. The nature of the formation to be penetrated is the deciding factor in the selection of bits, and a wide variety is tailored today for every conceivable kind of formation.

Early bits. The only bits available during the early days of the rotary were drag and disc type bits. Most common was the two-way, or fishtail, drag bit, which was shaped like a double chisel. Three and four-way drag bits soon made their appearance.

Both the drag and disc bit quickly ground down when hard rock was encountered. Twist-offs were frequent. Consequently, rotary drilling was limited to soft formations.



Evolution of rotary bits, from left to right: A two-way fishtail bit; an early disc bit, the first rock bit introduced in 1909, a modern conventional rock bit, today's jet rock bit, a chert bit, and a diamond drilling bit.

Rock bits. Introduction of the Hughes-Sharp two-cone rock bit in 1909 overcame the rotary's inability to drill hard formations, and it had much to do with increasing the popularity of rotary drilling.

Bit progress has been rapid and continuous since that time. The first four-cutter bits and the first cross roller bits were in use before 1920. Rock bits in various shapes and designs have grown in versatility, performance and use. Modern models of these bits have proved themselves in every known formation.

Prior to the 1920s, bit cutters operated on ineffective oil lubricated friction rings. Modern bits use roller bearings, and are lubricated by the mud-laden circulating fluid. Introduction of mud-lubricated rock bits in the 1920s eliminated the need for oil reservoirs within the bit housing, making it possible to design bits with lighter yet stronger bodies. The first roller bearing rock bits also were introduced during the 1920s. The three-cone bit came in 1933.

Better metallurgy. Introduction of hard facing materials in the manufacture of rotary bits during the 1920s

materially increased their hole-making ability. Cutting teeth now had longer life and greater strength.

The history of rotary drilling bits has been an example of major improvement through continuous advancements in harder, more wear-resistant metals and in design.

Jet bits. A significant development of recent years has been the jet bit. Experiments began as far back as 1938 with the principle that a greater flushing action would increase drilling speeds by washing the cuttings from under the bit more quickly. However, early tests were handicapped by hydraulic limitations in the mud circulatory system.

Experiments with jet drag bits in 1946 and 1947 proved so encouraging the idea again was tried on rock bits. Jet rock bits now are in wide use, especially in soft and medium hard formation.

Chert bits. Difficulties in drilling extremely hard formations resulted in chert bits in 1951. Prior to this development, the best rock bits were able to make only a few feet of hole in a West Texas formation containing pyrite.

The chert bit used rounded carbide inserts in place of the usual sharp teeth. This overcame the frequent breaking of teeth, and also proved an effective hole-maker. Development of deep West Texas fields no longer is retarded by the inability to drill this exceptionally hard formation.

Since its initial use in West Texas, the chert bit has come into wide use in drilling hard and semi-hard formations in many areas.

Diamond bits. As early as 1917, diamond bits had been used in drilling operations by the oil industry. Until mechanical means of setting diamonds in the bits took place in the 1930s, they were too expensive.

In the early 1940s, diamond bits were being used for drilling hard formations in several areas. Additional improvements have increased their performance in the intervening years.

Greater bit weights. Improved bits have made possible the utilization of greater bit weights which, in turn, has played an important role in faster penetration rates.

Through the use of an increasing number of drill collars, bit weights amounting to 10,000 pounds per inch of bit diameter are not uncommon in hard formations today.

MAJOR ADVANCES IN DRILLING FLUIDS

Development of water-clay, starch, oil-base, oil-emulsion, and other types of drilling fluids has played an extremely vital role in drilling progress. Many improvements in basic mud types have transformed them into "jacks of all trades." They lubricate and cool the bit, remove bit cuttings from the hole, support hole walls, prevent blowouts and loss of circulation. Without the specialty "tailored" muds for every conceivable condition, modern drilling would be far less efficient.

In 1957 alone, 1.2 million tons of barite and 550,000 tons of bentonite were used by U.S. and Canadian operators at a cost of $180 million. In addition, large quantities of other additives are used.

Early strides. Development of drilling fluids has been marked with a long series of major "break-throughs." Among the first was the recognition by drillers that muddy water provided better cutting removal than clear water. This led to the use of local surface clays in the early days of the rotary. The Hamill brothers, drillers on Lucas' Spindletop gusher, used cattle to create a mud mixture.

But no recognition was given to other functions of muds for some years. Sloughing walls gave rise to great difficulties. Frequent stuck pipe was a definite obstacle to drilling operations.

The first real mud engineering development came in the 1920s. Tremendous advancements in mud control and conditioning in subsequent years contributed materially to more efficient rotary drilling.

Weight and viscosity controlled. Another "breakthrough" was in the recognition of the part a heavy mud would play in controlling high formation pressures. By adding high density solids mud weight was increased sufficiently to provide a hydrostatic head greater than formation pressures. Ben Stroud of Louisiana received a patent on this development in 1926.

The next major improvement was the application of high colloidal content clay, bentonite, to stop caving and prevent stuck drill pipe. First recorded use of bentonite was in a Kettleman Hills, California, well in 1928. Credit for its initial conception goes to Philip E. Harth, although he had nothing to do with its first application.

Henceforth, the control of drilling fluid properties was to be one of the most important steps in safer, faster and more economical drilling.

Testing and control. Concurrent with these developments was the realization that control of mud properties was vital to satisfactory rotary performance. This led to the development of testing apparatus, which aided in diagnosing troubles and prescribing treatment. In addition to the control of viscosity and weight, mud engineers soon were concerned with such properties as gel strength, gel rate, sand content, wall-building properties, and hydrogen-ion concentrations.

H. N. Marsh developed the funnel for viscosity measurements in 1930. By then, the hydrometer had been adopted in lieu of a spring balance and rusty bricket for density measurements. Some studies had been made on the solids content of fluids by using a screen analysis and a centrifuge. Lime, sodium silicate and sodium hydroxide were studied as treating agents for increasing viscosity.

Between 1930 and 1935, many engineers and chemists made notable strides in drilling fluids. Quebracho, hemlock extract, other tannins, and phosphates were studied and tested as thinners, or viscosity reducing agents. Several rotary type viscosimeters were utilized in studying flow properties and gel rates. Equipment to study dy-

namic filtration in the laboratory was developed. From this stemmed the static pressure test, earliest field filter press.

By 1937, the mud balance and the filter-press were on the market. Torsion shearometers were being applied in drilling fluid tests to determine the yield point. In 1938 a code for testing drilling fluids was tentatively adopted by the API.

The Stormer Viscosimeter was developed in 1941, and proved an aid in the control of viscosity and gel strengths. The multispeed V-G meter, introduced in 1953, represented another forward step in the study and control of viscosity.

Drilling heaving shales. One important mud accomplishment is the minimizing of heavy shale problems. The literature of the 1930s and early 1940s is full of troubles with this formation.

The first sodium silicate muds were used successfully in 1935 to penetrate these "impossible to drill shales."

Great progress has been made in drilling heaving shales. Developments that have minimized problems of heaving shale are filtration control, viscosity and gel control, and chemicals in solution which inhibit the swelling of hydratable formation clays. Another contributing factor has been the development of high weight muds.

From 1936 to 1938, two or three oil-base fluids were developed as specialty fluids to drill troublesome shales and for use as coring and completion fluids to prevent damage to water-sensitive producing formations.

A new shale control mud designed to prevent shale hydration and thus provide well bore stabilization was placed on the market in 1956. This calcium treated mud now is in general use, and performance data indicate it is a major advancement in solving shale problems.

Combatting salt. High-pressure salt water flows marked the end of drilling for many years. The first step toward overcoming this problem was the introduction of salt gel in 1936, which improved the viscosity in salt brine drilling fluids.

Introduction of organic colloids in the form of modified starch in 1941 was another forward step. This made possible the maintenance of normal filtration in the face of salt contaminants that destroyed the effectiveness of clay colloids. It also allowed the compounding of muds with much lower filtration than was possible with previously known compositions.

A major "break-through" was the development of muds that could be controlled as to viscosity, gel, density, and filtration in the face of high-pressure salt water flows. This was the lime-treated muds that came into use in 1944. These muds have been the subject of many modifications and improvements in subsequent years.

Calcium contamination. The problem of designing a mud that would not be affected adversely by soluble calcium contamination has led to several "break-throughs." First of these was the use of barium carbonate in 1943. The next major advancement was the so-called gyp-mud, which provided means of controlling the contamination rate.

Gyp-mud was subjected to major improvement in the control of viscosity, gel and filtration by the addition of ferrochrome lignosulfonate in 1956. Control with this additive is effective in the presence of both gypsum and salt, and has allowed an increase in the density of the mud, when needed.

High temperatures. High bottom-hole temperatures have become a severe problem in extremely deep drilling. They can cause the solidification, or gellation, of some muds.

Temperature stable surfactant muds were introduced in 1953. They have proved capable of maintaining their fluidity at temperatures of 450° F.

Control of fluid loss in surfactant muds was an early problem. But recent advances indicate this problem is being minimized and perhaps overcome by the application of new agents.

Abnormal pressures. As drilling has progressed to greater depths, abnormally high pressures have been encountered more frequently. Consequently, heavier mud weights have been developed for such conditions. Wells have been drilled successfully with mud weights as high as 22 pounds per gallon.

In 1954, extremely high density weighting material having a specific gravity of 7.0 was introduced. Ultra-heavy muds with weights as high as 32 pounds per gallon have been used as well killing fluids.

Lost circulation. Drilling operations long have been plagued by lost circulation returns. Although advancements have been made in reducing the trouble, the problem still exists.

Among the advancements are the development of numerous plugging and bridging additives and materials, and the development of low-weight muds, including aeration, low solids, emulsions, and air or gas drilling.

Application of crushed-limestone filled bridging bags has proved effective in cavernous zones in a number of wells. After the cavern is bridged by the limestone particles, a seal can be effected with conventional lost circulation material.

New tools for locating the thief zone should further reduce the cost of the lost circulation problem.

Oil drilling fluids. Introduction of oil-base muds, stable oil-in-water emulsions and water-in-oil emulsions are other mud developments. Rock bit life has been extended through improved lubricating quantities of the mud, thereby reducing the number of round trips. Also, penetration rates have been increased by such muds which also aid in protecting producing formations containing clay from permeability impairment. The wetting of the bit teeth with oil also is believed to aid penetration by continually exposing clean cutting edges since shales are less likely to adhere to oil-wet teeth.

The first intentional addition of oil to a mud occurred in 1942, but soap-type emulsifiers were not used generally until the late 1940s. Non-fluorescing emulsion muds were first developed in 1951.

Invert emulsions which could be prepared easily in the field were introduced in 1952, and have come into general use.

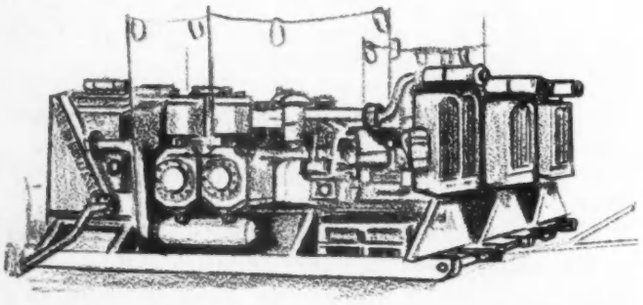
In 1955 and 1956, clear water or low solids milk-emulsions were found to increase penetration rate in hard rock country.

Application of extreme pressure lubricants to drilling fluids began in 1957. Bit bearing lubrication provided by these E. P. additives extends bit life under very high drill collar loads. This eliminates some of the trips for bit changes which results in faster penetration rates.

AIR AND GAS NEWEST CIRCULATING MEDIUMS

One recent step in rotary drilling has been the use of air or gas, instead of mud, as the circulating medium.

Use of low density drilling fluids to control fluid loss and prevent contamination of producing formations suggested other possible functions. Experiments in the use of low density drilling fluid date back to 1938, when aerated oil was used as the circulating fluid in several wells. However, it was 1951 before gas was utilized as the circulating medium on a large scale in the San Juan (New Mexico) Basin. Since that time, either air or gas has been used on an increasing number of wells in the United States.



Three completely self-contained, skid-mounted, diesel engine-powered compressors for air or gas drilling.

Need for a cleaner completion method and for a solution to lost circulation problems led to the initial use of drilling with gas in the San Juan Basin—a move credited with making production at San Juan economically feasible. However, other benefits soon were noted. Faster penetration rates, longer bit life, fewer round trips, better control of lost circulation, and cleaner producing zones are the principal advantages of air and gas drilling. The most impressive advantage is the phenomenal penetration rates, which generally have been 100 to 400 percent greater than those obtained with mud. It has not been uncommon for 50 to 75 percent fewer bits to be required.

Unfortunately, there also are undesirable characteristics. Neither air nor gas drilling gives much support to sloughing formations; consequently, neither has been used in areas where such zones occur. They cannot cope with all water bearing formations, and are of little assistance in controlling high pressure formations. There also is increased danger of rig fires, but precautions can make the operation reasonably safe. Dispersal of dust is another problem.

Controlling Fluids. The major deterrent of air or gas drilling is the inability to control the influx of formation fluids, particularly water. However, major progress is being made in this direction. Once this difficulty is solved, air or gas drilling probably will be used to a greater extent.

If sufficient air or gas at high enough pressure is available, it is possible to blow water and cuttings out of the hole. But disadvantages of this method make alternate procedures desirable.

Now that a new type of solids injector has been developed, injection into the air or gas stream of dry, finely ground stearates of zinc or calcium has been found to prevent "balling" of cuttings in the presence of water production ranging up to two barrels hourly.

Use of nonionic foaming agents has proved effective where water flows of 2 to 60 barrels per hour exist. Use of a foaming agent for removing water has made possible the continuing of air or gas drilling in several wells.

The problem of dust dispersal has led to the design of separators which trap cuttings. Periodically, cuttings are blown from separator traps.

In air and gas drilling, compressors supplant mud pumps. Otherwise, conventional rotary rigs can be converted to air and gas drilling with few changes. A simple manifold controls the supply and direction of flow. A circulating head is placed on top of the regular blowout equipment to effect a packoff around the kelly and prevent returns from blowing through the rotary. A 6-inch to 8-inch flow line carries dust cuttings about 200 feet from the rig.

Aerated muds, in which a combination of air and mud is used, also have given promising results, yielding good penetration rates.

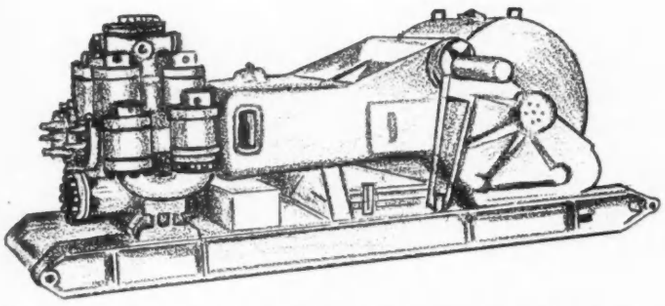
BETTER SURFACE MUD SYSTEMS

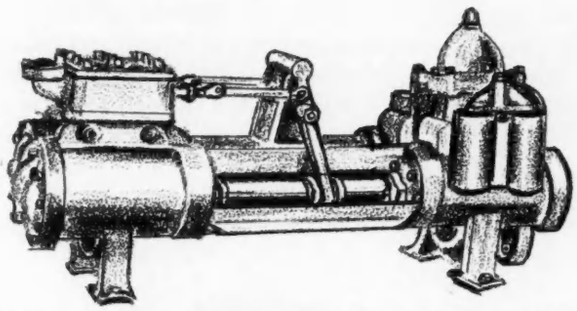
Continuing improvements have made mud circulating systems more powerful and efficient. Since this is the heart of the rotary drilling system, these steps have contributed substantially to better rotary drilling.

Better pumps. The first mud or slush pumps, in use around 1900, were 8 x 5 with 10-inch strokes, weighing only 2,000 pounds. They were directly driven by steam.

The largest slush pump in 1928 was capable of delivering 225 horsepower. By 1935, horsepower had been increased to 350. Soon after World War II, mud pump horsepower underwent further and rapid growth. Today, steel power pumps of 1,500 horsepower, with 20-inch strokes and discharge pressures of 3,000 pounds are in use on larger rigs.

Deeper drilling required larger pumps to circulate mud. However, the use of more powerful pumps was, to a considerable extent, the result of a better understanding of the importance of hydraulics in removing cuttings from the hole. In this connection, more attention has been given the whole drilling string during the past decade. Searching efforts have been made to remove all obstacles that restrict the size of the circulating system, including elimination of sharp bends and introduction of larger diameter tool joints, drill collars, rotary hose, etc.





Modern heavy-duty, 18-inch, 1,250-horsepower geared power mud pump, weighing 60,000 pounds, capable of developing from 2,000 to 3,600 pounds pressure (left). At right, a 10-inch stroke steam-driven duplex mud pump of 1907, weighing less than 2,000 pounds, featured removable cylinder liners, and was capable of operating at 125 to 175 pounds pressure.

The purpose has been to get a greater volume of fluid to the bottom of the hole for more efficient removal of cuttings.

Mud pressures in use around 1920 were in the range of 300 pounds per square inch under normal drilling conditions. The average pressure 20 years later probably was in excess of 800 pounds. Today, under extreme conditions in soft formations, mud pressures have been boosted to 2,000 pounds per square inch.

From early direct steam drives, mud pumps progressed to gear units using V-belts and chains. Later, hydraulic couplings and torque converters came into general use. They proved beneficial, lowering mud pump maintenance by absorbing shocks harmful to the pump.

Stronger hose. Every part of the mud system had to be strengthened to withstand higher pressures. For example, the rotary hose currently in use evidences a vast improvement over the flimsy water hoses used shortly after the turn of the century.

Before 1920, rotary hose generally was a good grade of wrapped-ply water hose with a wire reinforcement over the cover. It had a bursting strength in the range of 1,000 or 1,500 pounds per square inch. The next advancement was to imbed the wire reinforcement in the cover, and to use more piles of stronger rubber-impregnated fabric. Bursting strength was advanced to 2,500 pounds.

In the late 1920s came the introduction of multiple-helix, cable-wire, and all-steel types of hose, which—with improvements—are in use today.

Larger interior openings and non-friction flow characteristics are other major advances in rotary hose. Whereas the hose of 1920 had a 2-inch opening that was further restricted by smaller end nipples, the modern hose ranges up to 4 inches in diameter with bursting strength of 5,000 pounds.

Improved surface control. Circulating system efficiency has been improved by development of vibrating or rotating mud screens. These facilitate the separation of drill cuttings and sand and liberate excessive gas from the mud. Centrifugal units also are used for this purpose, in addition to being utilized to recover weighting materials for use on other wells. These devices permit better control of the mud properties. Too, by removing abrasive materials, they prolong the life of pumps, hose, swivels, etc.

In contrast to cattle milling around in the pits at Spindletop, modern mud preparation is accomplished by dumping commercially prepared materials into a hopper equipped with a high speed fluid discharge jet.

In the pit or tank, materials are blended by thorough agitation with the use of nozzle-equipped mud guns and mixers capable of rolling the entire contents of the pit.

Use of steel tanks and steel flow ditches, instead of earthen pits and ditches, has assisted in better mud control.

BLOWOUT EQUIPMENT A BIG AID

Since man began drilling into the earth, his greatest fear has been a blowout. This is as true today as it was 100 years ago.

The most effective way to prevent blowouts is to circulate properly conditioned mud of sufficient weight to control formation pressures. However, any one of a number of factors may cause a well to blowout. Therefore, blowout prevention equipment for use in such emergencies is essential.

The first known blowout preventer was designed in 1882 by M. A. Lanagan. It was a gate valve made for cable tool drilling, which sheared the line and closed the well.

From then until 1950, more than 10,000 patents were issued in an effort to find a cure-all for blowouts.

In 1903, using the basic method of the gate valve, two half gates, or rams, were developed. Long shafts were attached to the screws so the gates could be operated some distance from the well. This double gate preventer was used several years.

An inserted packer type preventer appeared in 1911. It consisted of a cone of lead forged to fit the pipe and split in half longitudinally. Each half was attached to a handle so it could be closed around the drill pipe.

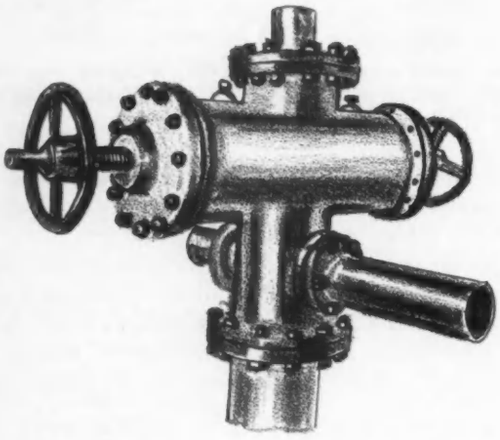
By 1928, steam cylinders were added to some ram type preventers, thus improving the speed in closing preventer valves. A packing head preventer was developed in 1931.

A radical change in the sealing of the cylindrical type rams came in 1935. A block of rubber was introduced to extend across the face and down the sides of the rams. This added volume of sealing material permitted movement of the pipe an made the rams function more like the packer type.

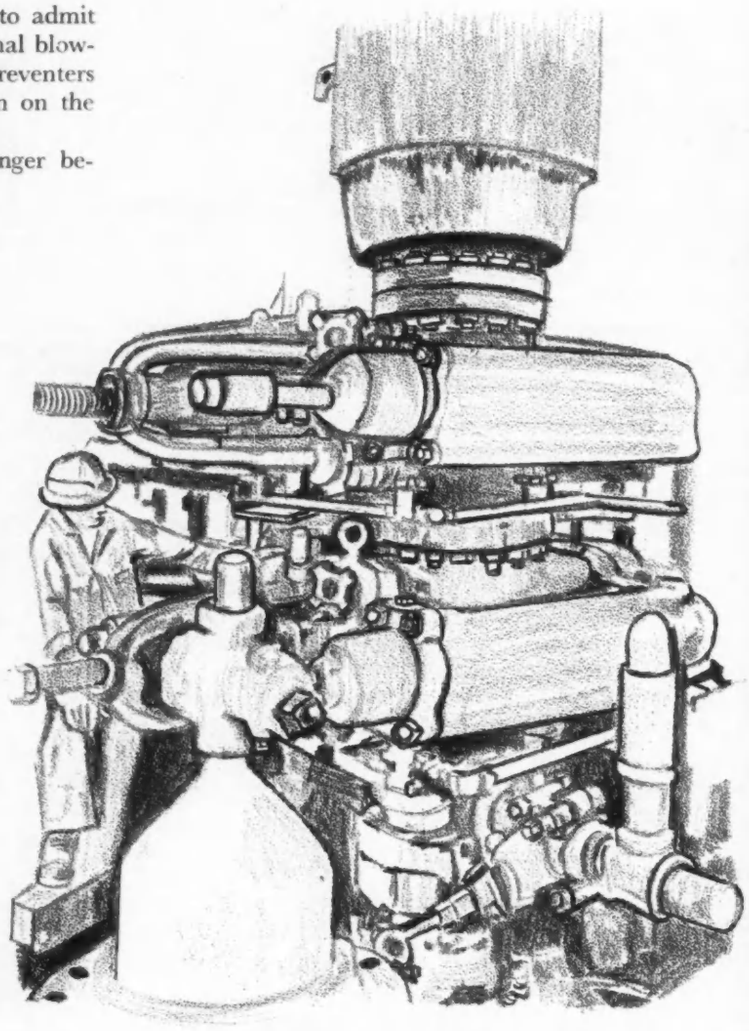
The modern blowout preventer is made of the highest grade steel, and it can work efficiently against extremely high pressures. It permits drilling crews to quickly close

an open hole on any type of drillstem or tool, to admit a mud column under pressure, to install additional blowout preventers. Modern installations include preventers hydraulically operated from the driller's position on the rig floor.

However, blowouts always will remain a danger because of the human factor.



The 1921 blowout preventer above was designed in the form of a cross, with two plungers that closed around the pipe. When drilling in extremely high pressure areas today, well controls may include three blowout preventers, as seen at right.



FROM WOOD TO PORTABLE STEEL DERRICKS

From the Drake well until almost the turn of the century, derricks were merely wooden boards held together with cut nails. The Drake derrick was 35 feet high, 12 feet square at the base and 3 feet square at the top. It was hewed from timber cut near the drill site. Crude hand-made structures such as this dotted the oil area countrysides for more than 40 years.

Major improvements in wooden derricks during this time included the use of weather treated wood and neater, sturdier manufactured models which replaced the hand carpentered structures. In 1899, the wooden derrick was first put together with bolts instead of nails. This aided greatly in erection time.

Steel to aluminum. Steel derricks were introduced to the oil industry in the early 1890s. The tubular steel derrick soon followed. Both types were bolted together in the early days. Some years later, derricks were galvanized for protection from the elements. Steel derricks first were used on pumping wells. It was not until about 1907 that the steel derrick was considered for drilling operations.

A 1928 rotary wooden derrick is shown at far left. At right is a heavy-duty rotary rig, with steel derrick and substructure, capable of drilling below 20,000 feet.

The wooden derrick continued to be the most widely used for some time. However, with deeper drilling and improved design, the steel derrick grew in popularity during the 1920s, and by the 1930s had, for the most part, replaced wooden structures. The first aluminum derrick appeared in 1954.

Larger and stronger. One advantage of the steel derrick was its strength for handling the increasing loads of deeper drilling.

From Drake's 35-foot derrick, some wooden rotary derricks had reached a height of 122 feet by 1920. They could handle loads of several hundred thousand pounds.

To accelerate make-up and break-out of long drilling strings, the modern derrick has risen in height to 200 feet. To provide more working space, bases on large derricks have been increased to nearly 40 square feet. And load capacities of as much as 1½ million pounds are being handled.

The value of equipment standardization is evident from the reduction of more than 200 different sizes of derricks formerly produced to less than a dozen today.

Substructures replace cellars. Early derrick foundations were made of several pieces of very heavy wooden timbers, latticed beneath the four corner legs of the derricks. Concrete later replaced the wooden timbers.

During these days, the derrick was not elevated, and it was necessary to excavate cellars to accommodate drilling control equipment. Cellars became larger and deeper, as drilling depths progressed and the use of more massive control equipment became necessary.

The expense of excavating cellars was eliminated in 1928, with the introduction of modern steel substructures. An additional advantage was the safety feature of having all control heads above ground level, where they were readily available for inspection, operation and maintenance. Substructures ranging upward to 18 feet are in use today.

Derricks to portable masts. One advantage of the steel derrick was that it could be torn down and be rebuilt for drilling other wells. With the development of efficient portable well servicing units, complete with masts, the industry was to take full advantage of this economy.

Oil fields no longer are recognizable by a forest of derricks. Normally, derricks now are removed from producing wells, leaving only the Christmas tree and other producing facilities at the site.

This development led to the introduction of the truck or trailer mounted portable rotary rigs in the 1930s (see "Faster Moves with Portable Rigs" page 171). New jackknife and telescoping masts fitted beautifully into this economy picture. Another innovation was the advent of steel derricks that could be assembled horizontally on the ground, then raised to an upright position.

THE EVOLUTION OF PRIME MOVERS

Rotary drilling power has progressed far from its early beginning at the turn of the century, when a small single-cylinder steam engine permitted depths of only a few thousand feet. Modern rigs are engineered pieces of machinery carefully tailored and balanced throughout.

To satisfy the desire to drill to ever greater depths, rigs have become more and more powerful. From simple units equipped with a single 25-horsepower engine, they have progressed to multiple engine affairs capable of developing more than 2,000 horsepower.

The source of power has changed from entirely steam in the early days to internal combustion drives, steam, or diesel electric drives. The internal combustion driven rig is by far the most popular today.

Steam first power source. Simplicity and flexibility of the steam engine made it the universal source of power on drilling rigs until about 1930.

The first steam prime movers used on rotary rigs were single-cylinder 25-horsepower engines. Twin steam engines were in use by 1912. By the late 1920s, twin engines with 12- and 14-inch strokes and three 85-horsepower boilers of 100 to 125 pounds working pressure were providing 600 boiler horsepower.

By the early 1940s, the standard type boiler was a 135 to 150-horsepower unit with working pressure of around 350 pounds, and some with 500-pound working pressure were in use. Twin-cylinder engines at this time were available in 2,000 horsepower, built for 350 to 500 pounds of steam pressure and high superheat. Vertical steam engines came into use during the late 1930s.

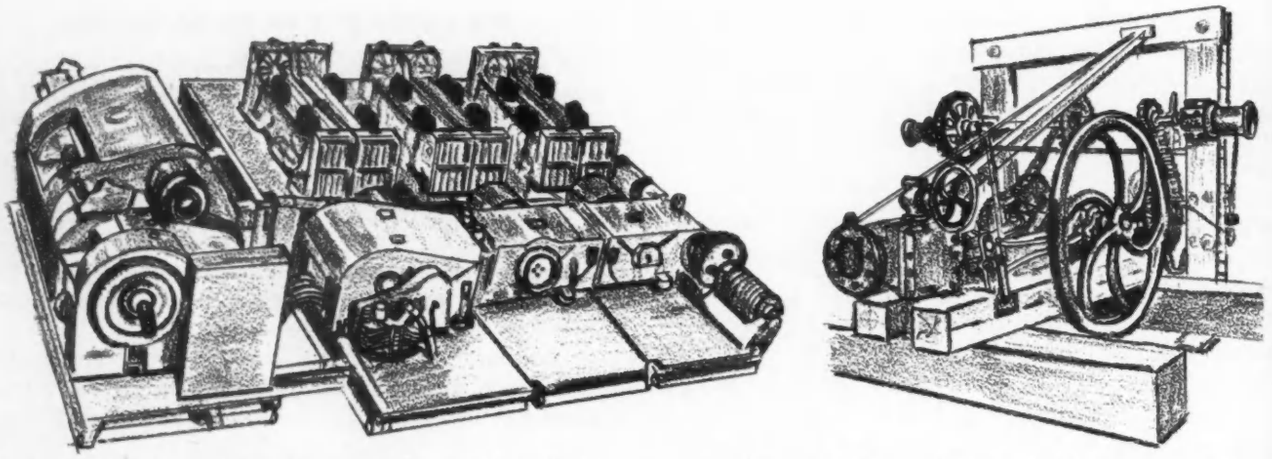
Use of superheaters, of completely insulated steam system, and preheating of boiler feedwater provided many advances in heat conservation during the 1930s. Nevertheless, steam engines still had an efficiency of only about 17 percent.

The increase in power made steam boilers massive pieces of machinery. Boilers alone had increased to weights of 40,000 pounds. Weights of other component rig parts had risen proportionately. Another drawback to the steam engine was the tremendous consumption of both water and fuel.

Shift to internal combustion rigs. Widespread use of the automobile had resulted in vast improvement of internal combustion engines by 1920. A wide range of engines was becoming available, some with sufficient power to be used for rotary drilling.

The oil industry began to think of using the internal combustion engine for rig power. And its first use for drilling was in Oklahoma during 1918, when gas engines drilled some wells to more than 1,000 feet. The diesel engine was tried in California during 1925-1928.

Internal combustion engines were only in limited use during the 1920s, although they proved to have higher efficiency than steam rigs. The primary reason for their



Today's multiple internal combustion engine, with hydraulic drive to drawworks (left). A 15-horsepower steam engine direct-connected to open drawworks in early 20th Century fashion is shown at right.

slow acceptance was their inability to move heavy loads from a dead standstill during hoisting operations without causing mechanical failures due to the impact of shock upon equipment. Steam continued to be the favored power source because of its ability to perform this necessary drilling chore.

First hydraulic drives. With improved transmissions and engines, the mechanical powered rig came into its own with the advent of fluid couplings and torque converters. These hydraulic drives reduced shock loads, preventing extreme instantaneous overloads on various driving elements.

The first fluid drives were applied to rotary drilling rigs in the late 1930s. At the outset, hydraulic couplings were available in wide horsepower ranges, while converters were limited in capacity and were plagued with mechanical difficulties. Consequently, the use of converters was limited to smaller rigs.

During World War II, torque converters were redesigned for greater durability and in wider capacity ranges. Since the charactertistics of the converter were well adapted to the hoisting functions of a drilling rig, they soon were accepted widely for use on small and medium depth rigs. Hydraulic couplings, developed for capacities up to 700 horsepower, compared with 300 horsepower for torque converters, have continued in favor on large rigs.

It was not until 1950 that the first rig was equipped with electro-magnetic, eddy-current type couplings, which can be operated independently or in unison from a master control panel.

The compounding of internal combustion engines for driving drawworks and mud pumps also took place during the late 1930s. This developed through the use of V-belts, chains and gear boxes.

Variety of engines. All types of internal combustion engines are used in rotary drilling operations today, including full diesels, semi-diesels, natural gas, butane, propane, and gasoline engines. The ability to convert these engines to the use of two or more different fuels has been an important development. Even the diesel can be operated on gas. This was made possible through a special combustion chamber, a gas mixing value, and an electrical ignition system.

Internal combustion engines now are available in a wide range of sizes. With the ability to compound multiple engines into efficient drives, sufficient mechanical power is available for any depth of drilling.

Diesel-electric comeback. Through new improved designs, diesel-electric rigs have come back into the drilling picture in recent years.

But electric drives on rotary rigs are not new. The first using variable speed alternating current was applied in 1915. Controls of these early electric rigs were cumbersome, complicated, expensive. High tension lines had to be readily available. As a result, electric power did not achieve great popularity.

The first diesel-electric powered rotary rig made its appearance in 1929. It consisted of two 125-kilowatt generators connected to slow-speed diesel engines. Direct-current motors were better adapted to drilling requirements than alternating current because of greater flexibility, better speed control, and ability to develop high torque at low speed.

A number of installations of widely varied design, some using a large number of smaller generators and engines, appeared during the next several years. These early direct-current drives utilized general purpose industrial motors and generators designed for other applications. Consequently, they were expensive and complicated. Meanwhile, mechanical rigs grew in popularity with the introduction of hydraulic couplings and converters. Interest waned in diesel-electric rigs.

Due to the flexibility permitted in arranging the component rig parts, the diesel-electric continued to be used to some extent for marine barge drilling operations in the marshes of southern Louisiana. This flexibility revived interest in the diesel-electric when offshore activity in the Gulf of Mexico got under way in earnest in 1947. A number of the offshore mobile units employed diesel-electric power.

The first electric drive system specifically designed for rotary drilling did not appear until 1955. Locomotive or traction type motors were suitably modified for drilling. Since they were produced on a mass basis, they were offered at prices appreciably below equivalent industrial motors.

Originally, tractor type electric equipment was available only in large sizes. This limited its use to offshore operations. However, by 1956 diesel-electric rigs were going portable. Smaller engines and power generating equipment were being mounted on trailers.

A diesel-electric power rig for 7,000-foot drilling with 4½ inch drill pipe, 3-speed drawworks, utilizing a 625-horsepower motor was seen in the fields. The rotary table was driven by the same motor through a spiral bevel right-angle gear box. It could be mounted on three trailers. Such units soon were available in lightweight, compact packages, which could be used singly or in multiples.

One of the most powerful rigs currently in use is a diesel-electric capable of drilling to 25,000 feet with 5-inch drill pipe. Power is furnished by three diesel-engine driven direct current generators, rated at 814 horsepower on continuous service and 1,020 horsepower on intermittent service. Despite its tremendous size, the rig is portable and simple to operate.

FASTER MOVES WITH PORTABLE RIGS

The disproportionately large amount of unproductive drilling time formerly spent in dismantling, moving and setting up a drilling rig at a new site has been shortened from days to hours. This money-saving advancement has resulted from the portability of equipment built to facilitate moving operations. As smaller rigs have gone completely portable, even the largest are far more so today than were the smaller rigs of 25 years ago. Increased mobility is of extreme significance because of the frequent moves made by drilling rigs.

Completely mobile rotary drilling rigs were introduced in the late 1930s. The entire drilling assembly, including engines, pumps, and steel derrick, was mounted on a truck.

The first portable rigs were confined to shallow drilling, but continuous improvement, including greater floor area and mast height, has made possible their use in deep drilling. Because of the mobility, portable rigs greatly reduce drilling costs. Consequently, they have gained in popularity.

An important part of this development has been the introduction of telescoping masts and cantilever jackknife derricks.

Portable rigs did not become feasible until the introduction of efficient portable well servicing units, complete with masts. This made it unnecessary to have derricks in place during producing operations.

Faster big rig moves. A great deal of advancement also has taken place in providing portability in the largest land rigs.

Unitization and skid mounting have played leading roles in this development. Up to 1934, drawworks were set up anew at every well site, requiring a considerable length of time.

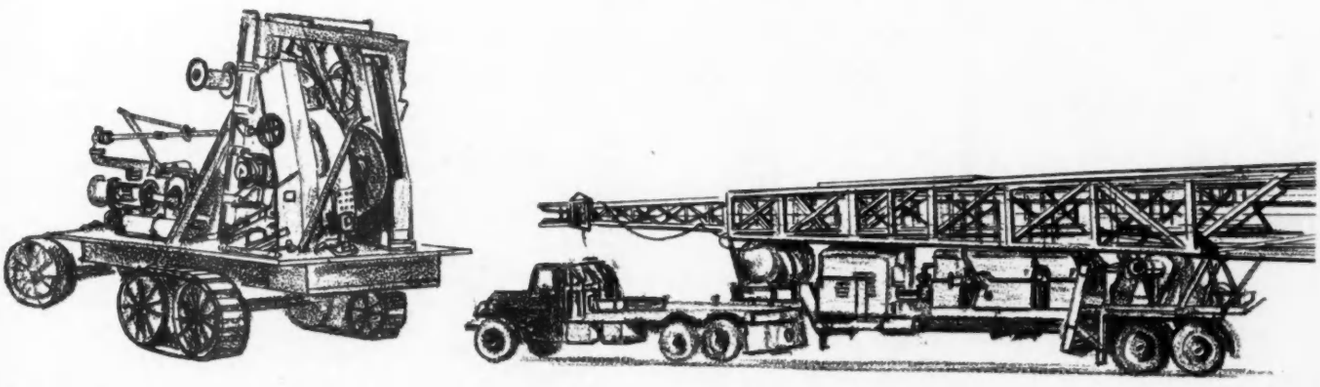
The first unitized drawworks was installed in the Conroe, Texas, field in 1932 by Hu M. Harris, drilling superintendent for Humble Oil & Refining Company. Unitary drawworks increased rapidly in the next few years. By 1938 they were being skid mounted. Almost immediately, various component rigs parts were skid mounted, with many related parts being put into consolidated packages. This speeded up moving, and reduced dismantling and erection time on big rigs.

As the trend toward greater portability continued, dual and triple trailer rigs have made their appearance. Drawworks and engines are placed on one trailer and pumps on another.

BETTER, FASTER HOISTING SYSTEMS

Refinements and improvements to rotary hoisting systems have been so numerous and outstanding that today's equipment bears little resemblance to that in use as recently as 30 years ago. This is another development which has played an important role in the safe, economic and fast deep drilling operations of today.

While fewer round trips are made today, due principally to improved bit performance and greater penetration rates, the time required for necessary trips has been reduced by faster hoisting operations. Meanwhile, drawworks, wire lines, traveling and crown blocks have been



At left is an attempt in the late 1920s to provide rig portability. Here, the drawworks and engine have been mounted permanently on trailer. Modern trailer-mounted rotary rig with telescoping derrick appears at right.

strengthened and improved materially to handle the heavy loads imposed by deeper drilling.

Early crude drawworks. Development of modern powerful, precision-engineered, high-speed drawworks into compact and completely enclosed units has been an important hoisting advancement.

The 6 x 8 two-post rotary drawworks of the early 1900s were crude pieces of machinery assembled in the field with each rig move. They weighed only 5,000 pounds, and consisted chiefly of many cast iron parts. Clutches were positive contact affairs, subject to frequent breakage and replacement. Brakes used hardwood blocks.

During the mid-1910s, drawworks were heavier and began to take on a few improvements. Shafts were made of cold drawn steel, with cast integral drums. Brake flanges had increased to 34 inches in diameter and widths to 8 or 8½ inches. Double brakes with asbestos blocks were introduced. Steel began to replace the old wooden posts. A rotary-drive clutch sprocket was offered, and some attempts were made to put clutch and brake levers in a convenient location.

Advances in 1920s. The enormous torque set up by the use of larger twin cylinder steam engines necessitated significant changes during the early 1920s. These included three-speed drawworks, a fourth post to reduce vibration, air-cooled steel brake flanges, and a foot lever to operate drum-shaft clutch sprocket.

By the end of the 1920s, conspicuous refinements and improvements had taken place. Shafts and sprockets were made of heat-treated alloy steel and used roller bearings. Automatic catheads had been introduced. Brake drums had increased in width to 12 inches, and in diameter to 60 inches. Some heavier-duty rigs used two brakes on the drum. The now common hydraulic brake first appeared in 1929, and was widely used by 1934. Some heavier units weighed 22,000 pounds, and were adapted to all types of prime movers. They were being recommended for 10,000-foot depths, which were to become a reality in 1931.

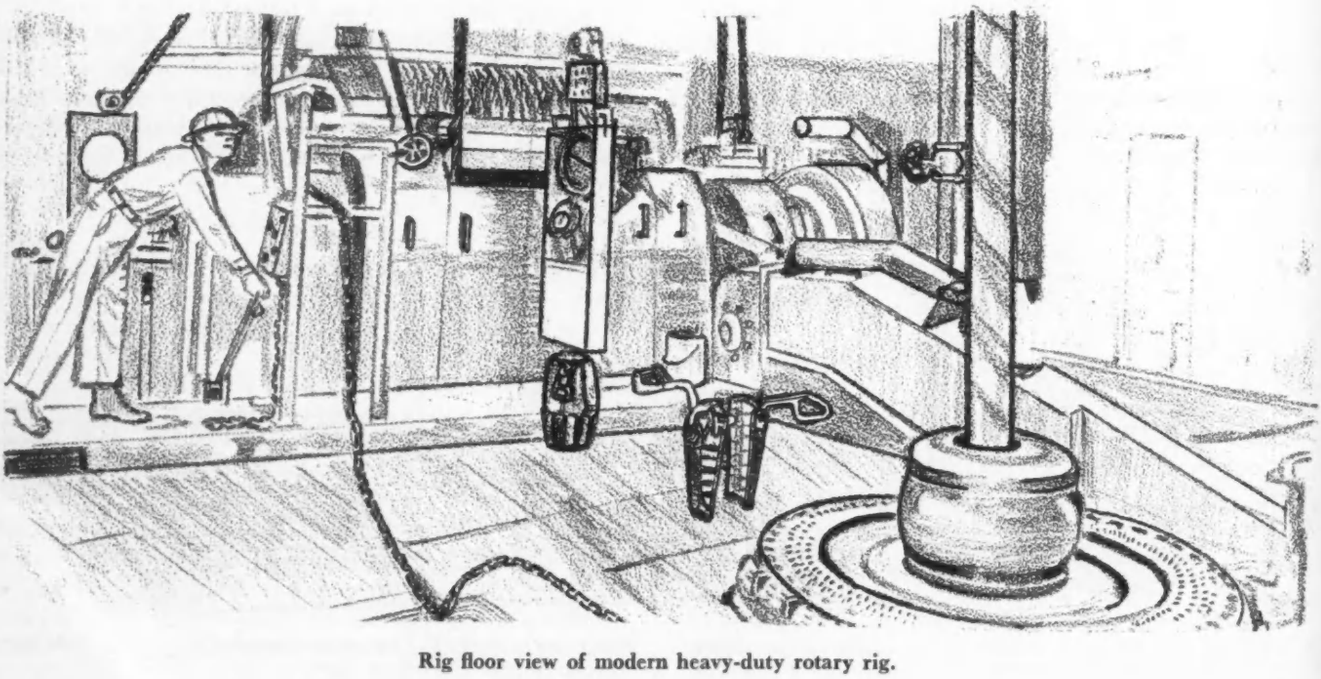
Unitized drawworks a big step. Outstanding improvements took place during the 1930s. As previously mentioned, the first unitized drawworks was installed in 1932, and skid-mounted units had arrived by 1938. This was an extremely important development. Not only was a great deal of time saved in erecting and dismantling during rig moves, but also better alignment reduced wear on many parts.

Too, unitization made better lubrication possible, and oil baths for chain drives came into being. The fully enclosed drawworks of today was made possible by unitization.

Today's heavy-duty drawworks for 20,000-foot drilling likely is to be of two-section construction, providing six or more hoisting speeds controlled by air actuated clutches, with double-band water cooled equilizing 62-inch diameter brakes, in addition to large hydraulic or electro-magnetic brakes.

Air-operated controls. A feature of the modern rig, whether for deep or shallow drilling, is the generous use of air-operated controls for all rig operations. Manual operation of rig activity has passed from the scene. With the tip of a finger, it now is possible to regulate speed, power and activity of any part of the rig by controls conveniently grouped on centralized panels.

Some panels can be moved to any desired position on the rig floor due to flexible hose connections.



Rig floor view of modern heavy-duty rotary rig.

Such controls give the driller positive and instantaneous control over every rig operation, and have made rig floor work faster, easier and safer.

Improvements in blocks. Traveling blocks in 1940 were equipped with six 36- to 46-inch sheaves, and had capacities up to 350 tons. Sheaves were being carefully machined of high alloy steel to fit different size wire lines.

The heavier duty traveling blocks of today have capacities of 600 tons with six 60-inch sheaves. Efforts to design narrower blocks have kept massive modern units within reason, and some of the newer models are slimmer than earlier units of similar capacity.

Hooks and elevators necessarily have had to be increased in capacity to provide balanced hoisting systems. Early 1950s saw the introduction of streamline hooks which are unitized or directly connected to the traveling block.

Flexible, stronger wire lines. Historically, the first wire drilling lines were relatively stiff and inelastic 6 x 7 construction. These were replaced by lines of 6 x 19 construction, which was more pliable because of more and finer wire per strand.

Metallurgical advances have improved the physical properties of wire lines greatly. Today's high-grade alloy steel lines give far greater service than plain carbon steel. Performance of wire lines also has been helped by larger diameter, better machined sheaves in crown and traveling blocks. Better understanding of the care and operation of lines has resulted in additional service life.

These advances have made it possible for modern wire lines to handle the heaviest loads through the use of an increased number of lines.

Blocks greatly refined. Improvements in traveling and crown blocks have consisted of better metallurgy, refined design, greater capacity, and addition of lubricating systems.

Early traveling and crown blocks had 16-inch wooden sheaves. These soon were replaced by larger cast iron sheaves.

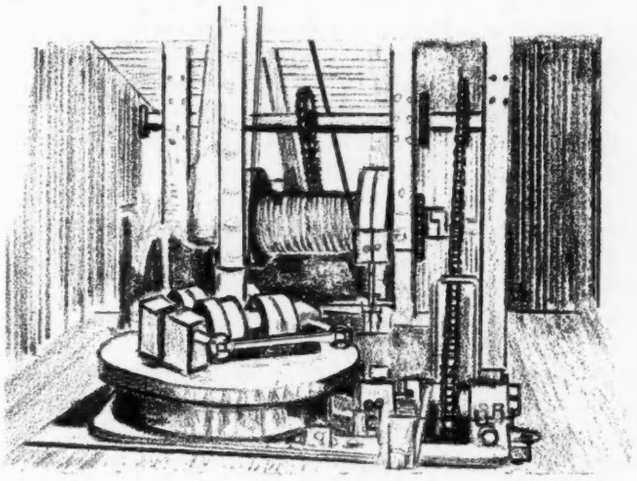
Until the early 1920s, blocks were constructed with 20- to 24-inch cast iron sheaves, bronze bushed, lubricated by pouring oil into a cup. Then came the introduction of efficient lubricating systems and the use of roller bearings. This provides greater speed, particularly when lowering unloaded blocks. At this time, 36-inch steel sheaves replaced the smaller cast iron sheaves.

Increased traveling block sizes created a safety hazard, often catching on the finger board and upsetting the derrick man. This limited construction widths. The first so-called streamlined, or elongated, traveling blocks appeared in 1912, and much progress in this direction had been made by 1920. Larger and taller derricks have helped to overcome this problem, but to this day block sizes must be confined to narrow limits. Consequently, the multiple deck traveling block came into wide use by 1940.

ROTATING MECHANISM IS REFINED

The first rotating equipment was almost more trouble than it was worth. Rotation was achieved by grip rings, or clamps, attached to the rotary table, which was turned by a system of sprockets and chains.

In 1912, the square kelly, kelly drive bushing and master bushing replaced the old round-pipe clamping method. This was one of the first major changes in rotary drilling. It provided a more efficient means of rotating pipe, and eliminated frequent interruptions to keep the bit on bottom.



The largest rotary rig operating in 1913 still used grip rings to rotate drill pipe and open chain sprocket drives for drawworks and rotary table.

Shortly afterwards, multiple sectioned rotary slips were introduced. These segments soon were made of fine heat-treated machined steel.

By 1923, a shaft-driven rotary, the make-and-break rotary table, and cathead had been introduced. This was the first step toward use of power in making up and breaking out joints of drill pipe. This greatly decreased manual labor, made rig floor work safe, and speeded up trip times.

By the late 1920s, spiral-beveled gears were being used which made possible the fully enclosed oil-bath rotary table in 1930.

OUTSTANDING STRIDES IN DRILLING STRINGS

Among the outstanding accomplishments in drilling equipment progress has been vast improvement in the quality and engineering of drill pipe, tool joints and drill collars. This undoubtedly has been one of the principal factors contributing to deeper and faster drilling.

Early pipe troubles. The first drill pipe was a low carbon butt-welded or lap-welded pipe with short couplings. There were no tool joints or drill collars.

Too frequent failures made such pipe unsatisfactory. Hot-rolled and pierced seamless tubes made of higher carbon was the first step toward better drill pipe. However, the short, fine-thread couplings could not stand the strain of constant making-up and breaking-out or the punishment during rotation.

The first heavy section tool joints were introduced in 1910 by M. H. Whittier. They were a great improvement over the thin, finely-threaded couplings used previously. In addition to providing thicker walled joints, Whittier's

joints had a coarse-pitched thread, which could be connected or disconnected by only a few turns. By 1912, tool joints were being made of alloy steel. Though an improvement, still stronger joints were needed. This led to the upsetting of pipe ends to compensate for material removed in threading.

Better pipe and joints. Heat-treated alloy-steel joints and the Acme thread were introduced in 1919. Drill pipe was improved further by increasing carbon content and by advanced heat-treating method. Still, there was much trouble, with one company reporting a drill pipe failure for every 750 feet of hole drilled in 1925.

Development of a joint with a larger inside bore began in 1924. The primary original purpose was to accommodate a retractable wire line drilling bit then in use. Continually larger inside openings have been developed since this time, but the main purpose in later years has been to eliminate restrictions on flow of circulating fluid.

In 1924, API adopted a thread profile having rounded crests and roots as standard for drill pipe, and established uniform pitch diameters and manufacturing tolerances. In 1927, API revised these standards, approving a standard known as the API regular tool joint, a modified version of which still is in use today. In the spring of 1934, API adopted final standards on four sizes of full-hole tool joints and tentative standards on external-upset drill pipe.

The past 25 years have seen continual progress in providing the industry with better, more durable drill pipe and joints. With the industry drilling deeper and deeper holes, the minimum yield strength of drill pipe has been increased in recent years to as much as 135,000 pounds per square inch. And experimental tests on even higher yield drill pipe are under way.

Metallurgy, manufacturing advances and engineering have contributed to this progress. Continuing research studies are aimed at providing better pipe and joints which will be needed in the future.

Applying tool joints. Early day drilling crews installed tool joints on drill pipe at the rig. This resulted in galled threads that caused failures. A method for machine bucking the joints on the pipe in shops under closely controlled conditions was developed in 1929.

The practice of welding joints to the pipe was introduced in 1933, and proved extremely helpful in preventing failures at the last engaged thread. This was followed soon by the development of other designs incorporating a mechanical support and seal between the joint and the pipe, in addition to threads.

In the late 1930s came processes by which tool joints were integrally welded or shrunk onto the drill pipe to provide unitized units of greater strength. Hard facing of tool joints also was a development of the late 1930s. Much progress has been made in the application of hard alloys during the intervening years. These developments have added substantially to the life of tool joints, and, therefore, to the entire drilling stem.

Lighter weight pipe. Use of lighter weight drilling strings has gained in popularity during recent years. Improved metallurgy and development of special tool joints have made this possible. The purpose behind utilization of light weight drilling strings is to make possible the use of lighter and less expensive drilling rigs.

The first light-weight drilling strings went into service in 1950, using standard tubing couplers. Failures in the couplings led to the development of special light weight tool joints. Such strings have been used to depths of 10,000 feet in eastern Venezuela.

Benefits from drill collars. Numerous twist-offs near the bottom of the drilling string led to use of thicker diameter pipe at this point. The first collars were merely overgrown subs about six feet long. The idea was to stiffen and strengthen the lower portion of the drill stem.

Through experience it was observed that several additional benefits resulted. During the late 1920s when crooked holes were a major drilling problem, drill collars were increased in length to about 40 feet. Increased stiffness contributed to straight-hole drilling.

The drill collar string had progressed to lengths of 250-350 feet by 1940. It was being noted that heavier weights increased penetration rates and assisted in keeping the drill pipe in tension.

Over the years, larger drill collars have been used to minimize hole deviation, while permitting the use of more collars to increase the weight on the bit. Use of 6-inch collars in 6¾-inch hole, 7-inch collars in 7⅞-inch hole, and 8-inch collars in 8¾-inch hole was common in some areas by 1956. Meanwhile, up to 30 drill collars had come into use in West Texas. The use of more collars had resulted in the application of bit weights amounting to 10,000 pounds per inch of bit diameter in hard formations.

Operating advances. Improvements in operating practices have helped metallurgy and manufacturing methods increase drill pipe life. In early days most drillstems were operated in compression, causing pipe to spiral and thus contact the walls of the hole, causing excessive wear.

Almost all drill pipe today is operated in tension. This keeps the string from spiraling in the hole, and reduces both wall wear and fatigue failures. Introduction of rubber drill pipe protectors in the late 1920s added to the life of drill pipe and tool joints.

Use of improved lubricants on tool joint threads has helped by preventing face-to-shoulder standoffs in making up drill pipe strings.

Automatic pipe handling. The speed, ease and safety with which drill pipe can be handled during round trips has been enhanced greatly during the past decade by the introduction of power equipment to perform such functions.

Semi-automatic power tongs were field tested in 1948. By 1952, hydraulically controlled fully-automatic tongs made it possible for one man to make-up, break-out, spin-up or spin-out the drill pipe.

Hand-operated power slips were introduced in 1942. Early models occupied too much floor space, hindering operations. Constant refinements have led to great im-

provement. Today, many rigs have power slips integrated with the rotary table as a unitized assembly.

Considerable work also has been done in the development of devices which automatically rack the drill pipe in the derrick. Devices first field tested in 1948 consisted of two electrically operated arms. The derrickman operated the upper arm from a movable monkey board, while the tong operator controlled the lower arm.

Power swivels became available in the mid-1950s. They were capable of performing many light rotation jobs, such as cutting casing, drilling out bridges, cement and other obstructions. Power swivels permit the addition of multi-joint stands of drill pipe during drilling operations, reducing the number of connections that need to be made.

BOTTOM-OF-HOLE BIT ROTATING EQUIPMENT

Attempts to develop a bottom-of-the-hole device capable of rotating the bit began many years ago. The earliest record is that of Dr. C. G. Cross, of Chicago, who obtained a patent for single-stage turbodrill in 1873.

The object of these developments has been to activate the bit at the bottom of the hole without depending upon a long, heavy drilling string for rotation power, obviating many of the difficulties and limitations of the conventional rotary drilling method. Most attempts have tried to utilize the circulating fluid for power, although others have used other means.

Spotlight on turbodrill. As the industry begins its second century, much attention is focused on turbodrilling. Extensive development of this method by the Russians during the past 30 years has resulted in it being used to drill 80 percent of the wells in the Soviet Union. U.S. interest in the turbodrill rose to a new high in the mid-1950s, with the introduction of the Russian drill into this country.

The first serious pioneering work on the application of turbodrills to oil well drilling began in the U.S. in the early 1920s. Much of this early work was by C. C. Scharpenberg, then chief engineer for Standard Oil Company of California. A patent was issued to Scharpenberg in 1924 on a simple multi-stage axial flow turbodrill, and field tests began in 1926. The first Russian patent for a turbodrill also was issued in 1924, but seven months after Scharpenberg's patent was issued. Unlike Scharpenberg's design, the Russian model was a single-stage high-speed turbine which was geared down through complex planetary gearing.

Frequent cutting out of bearing seals due to the abrasive action of the drilling fluid was the source of considerable trouble on these early U.S. and Russian turbos.

In 1935, the Scharpenberg turbo shaft was fitted with the first rubber radial guide bearings and redesigned ball thrust bearings at the bottom end. It was opened up to run directly in the mud without seals. By 1941, when the war interrupted work, five wells had been drilled by Standard of California with this model. In 1950, Standard resumed testing with essentially the same model. Between 1945 and 1950, another U.S. turbo was tested on five wells in the Mid-Continent region.

Russians had only limited success for 10 years. In 1935, they resorted to Scharpenberg's much simpler multi-stage design. Testing of this model led to increased development work and to many design changes. Russians radically changed bearing design in 1948, substituting sliding rubber thrust bearings for the steel ball bearings to permit the design of much heavier duty units. By 1950, the Russian turbodrill of today, except for modifications, had been evolved.

U.S. testing of the Russian turbo during the past few years has indicated that the design of bits capable of withstanding higher rotation speeds and heavier weights is one of the serious problems today. A concentrated effort on this and other turbo problems is being made today.

Vibratory drilling. Many attempts have been made to apply the principles of percussion drilling to rotary rigs, and experiments and tests have been intensified during the past decade. Again, the primary aim is to activate the bit with rotation of drilling string.

One of these devices imparts a reciprocating motion to the bit by employing an alternating magnetizing current to expand and contract a transducer column of nickle. The bit can be made to strike bottom at several hundred cycles per second.

Another device in the experimental stage is the sonic drill, in which the bit is vibrated at about 60 strokes per second. It utilizes a mud-driven down-the-hole turbo motor for rotation, and waves transmitted through a resonant steel column to impart vibrations to the bit.

Other bottom-of-the-hole powered bits also are under study. Among these is a fluid actuated 200-pound rapid-stroke hammer drill.

These are only a few of the more than 100 patents issued for a wide variety of rotary-percussion methods since 1902.

VAST STRIDES IN RIG INSTRUMENTATION

Instrumentation has played a major role in drilling progress since the mid-1920s. Until that time, the only gage, or indicator, on the rig was the steam gage on the boiler, and drilling operations were regulated entirely by the driller's intuition, or feel.

The primary objective in introducing a host of new instruments has been to increase the driller's proficiency by helping him drill straighter, better holes with greater speed and safety. Today, a dozen gages, indicators and recorders are located so the driller can tell at a glance whether various parts of the rig are functioning properly and if he is maintaining optimum operating conditions. Some instruments provide automatic control at preset rates.

Weight indicators. One early important step in instrumentation was the introduction of the mechanical weight indicator in 1926. It measured the contraction of the derrick resulting from the weight or pull on the drilling string.

This information was extremely helpful. It eliminated the old method of raising and lowering the drilling string a short distance to be sure the bit was on bottom cutting

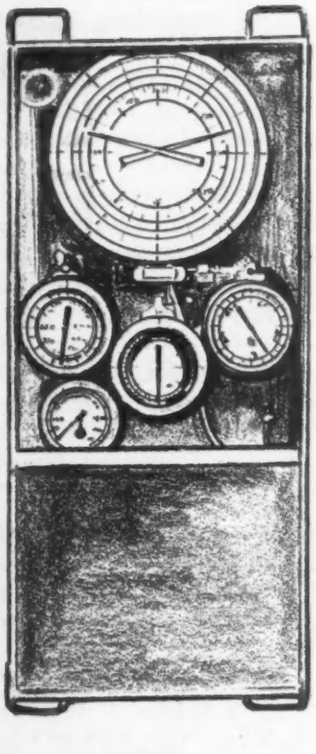
new hole and not rotating freely off bottom. This speeded up drilling operations, as the driller could tell immediately when he should lower the bit. Such information also registered the pull on the derrick, and thus helped to prevent pulling-in of the derrick when trying to lift stuck pipe.

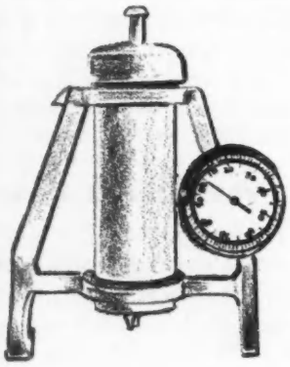
Great advancements have given the industry more sensitive and accurate weight indicators.

Automatic feed controls. A very important step in instrumentation was the introduction of automatic feed controls in 1925. These devices made possible the feeding of drill pipe into the hole at steady, constant rates, which would keep the bit on bottom cutting new hole all the time.

Modern automatic feed controls have become extremely sensitive to small changes in dead-line tension, and feed-off the drilling line automatically so the weight on the bit is kept uniform at pre-selected loads or rates of speed.

Automatic drilling controls provide for smoother, faster penetration, and relieve the driller of constantly standing with his hand on the brake lever to control the rate of feed. They also have extended bit life by preventing overloading.





The first weight indicator of 1926 (below) bears no resemblance to today's models with their additional gages that keep the driller informed on functions of several rig activities.

Drilling recorders. The first automatic pentration rate recorder was used experimentally in 1937. But it was several years before these instruments came into wide use.

These devices record the time to drill each foot. Such information has been found to provide considerable valuable data. Penetration rates indicate changes in formation that can be correlated with well logs, assist in planning drilling procedure, tell when bits are becoming dull, and are invaluable for making bit performance studies.

Other instruments. More and more instrumentation has taken place during the years. The latest rigs will have 10 to 12 gages and indicators located at the driller's position.

Indicators which measure torque in drill pipe will tell when a bit is getting dull and when a hole is tending to be crooked. By warning of excessive torque, they are important in preventing twist-offs.

Tachometers provide the driller with constant knowledge of rotation speed, enabling him to keep it uniform. Mud pump pressure gages reflect washouts or other circulation irregularities. Mud pump speed gages are valuable in getting optimum performance. They can tell when liners should be changed to restore output.

Tong-torque instruments have been developed which record torque applied by power tongs, thus preventing over-tonging or running of joints too loosely.

Use of records. Many of the rig instruments in use today provide permanent records. These charts have proved valuable in many ways, such as computing the number of hours spent on bottom, time spent making round trips, changing bits, etc. Correlated weight, mud and torque records make possible precise engineering performance studies that have led to more proficient drilling operations.

DRILLING STRAIGHTER HOLES

Little attention was paid to drilling straight holes in the early days of rotary drilling. During the late 1910s, there was increasing evidence that some holes drifted far off vertical. Difficulties in running casing and other troubles resulted from crooked holes.

Initial attempts to measure the verticality of holes in the U.S. was made in 1920 by using a bottle half filled with weak hydrochloric acid solution. When lowered into the hole and allowed to remain at rest a few minutes, the acid etched a line around the inside of the bottle. This indicated the approximate amount of deviation from vertical.

Additional data assembled in the early 1920s through the fairly general use of acid bottles confirmed previous indications that many holes were crooked. Alexander Anderson in 1924 introduced a specially designed instrument for determining the drift from vertical. The crooked hole problem became extremely important during the development of the Santa Fe Springs, California, field in the early 1920s, and the Seminole, Oklahoma, area in the late 1920s. The latter region produced some outstanding examples of crooked holes.

Intense studies. Now that it had become known that many holes were considerably off vertical, the industry began an intensive study of corrective measures. The Drilling Practices Committee of API distributed questionnaires on the subject in 1929, and published results of its studies the following year. Straight hole drilling

continued to be a top ranking study of the institute for several years.

These studies led to the development of drilling techniques which helped to keep holes straight. Among these were maintaining proper and uniform weights on bits, application of correct rotating speeds according to the formation and type of bit in use, and employment of heavier, stiffer drill collars immediately above the bit. Thus, many of the tools, instruments and methods described previously played important roles in straighter drilling.

In later years, stabilizers have been added to the drill collar column to help maintain straight alignment of the lower end of the drilling string and to minimize the tendency of the hole to deviate.

Deviation instruments. Knowledge that rotary drilled holes were crooked spurred many inventive individuals to design well surveying instruments.

By 1930, instruments using the fluid level principal for indicating inclination had been improved greatly. They were easier and safer to operate, and gave more accurate information than the acid bottle.

Through API studies, it had been shown that direction of verticality probably was equal in importance to the degree of verticality. So, by 1930 or soon thereafter, a number of instruments appeared which used gyroscopes, or magnetic compasses, to indicate the direction of vertical drift.

Oil men now could determine both the direction and inclination of drift from vertical. However, they needed instruments which would reveal smaller degrees of drifts and, at the same time, make continuous records at all depths to see if the hole tended to become more crooked or to straighten up. Several reliable instruments capable of performing these functions were not long in being introduced.

Modern instruments are fast and easy to run. Use of non-magnetic drill collars had made it possible to run them without withdrawing the drill pipe. Since they take little time to run, surveying of hole verticality often is done as a regular part of the drilling operation in many areas.

The latest concepts in vertical surveying instruments are devices which transmit signals to the surface when the bottom of the hole becomes crooked and electric surface recorders which make possible continuous denotation logs.

Correcting crooked holes. The first under-reamer was introduced in 1922 by John Grant during the Santa Fe Springs, California, boom. The tool, then as now, was used to smooth out rough edges and dog legs in crooked holes while bringing the hole out to full gage. It immediately proved helpful in running casing.

The reamer, to do the same job as under-reamers, was introduced in 1925.

DRILLING DIRECTIONALLY CONTROLLED HOLES

Experience with crooked-hole problems led to the development of purposely deflected holes to reach objectives not directly beneath the derrick. This has become a scientifically developed art with many uses.

Introduction of reliable vertical and directional instruments discussed previously made directional drilling possible. In addition, it was necessary to develop special deflection tools.

Multiple uses. The first purposely controlled directional drilling came into use before 1925, but was not applied widely until 1927.

Directional drilling is used to bring crooked holes back to vertical and to sidetrack lost tools during normal drilling operations. In addition, it has many specialized applications. Directional drilling is a key economic factor in the development of an offshore oil field, making possible the drilling of a number of wells from the same platform. One of the early uses was the drilling of high angle wells from onshore to develop California fields extending offshore.

Directional drilling is helpful in changing the drilling direction in faulted areas, on salt domes, etc. A spectacular use is the drilling of angle relief wells to kill wild or cratered wells.

The technique of directional drilling has been perfected through the development of a variety of whipstocks, knuckle joints, special bits, and other tools.

SIGNIFICANT PROGRESS IN FISHING TOOLS

The frequency with which parts of the drilling string are lost or stuck in the hole has been reduced greatly by advances in equipment and methods, but fishing jobs still—and always will—occur. Therefore, significant progress in the science of fishing has been important to the industry's constant struggle to reduce drilling time.

Advances in jars. One of the oldest known fishing methods was by jarring or hammering on stuck objects. Cable tool jars, conceived in about 1865, could strike little more than a sledge hammer blow. Weldless cable tool jars appeared shortly before the turn of the century, and, by the early 1920s, had supplanted less efficient welded link construction.

Torque jars appeared in the early 1920s. The original Kammerdiner jars of 1924 were the first to combine tension and torque in such a manner that energy could be stored in the pipe and be released suddenly. This tool produced impacts many times greater than possible previously. A more flexible tool appeared in the late 1930s.

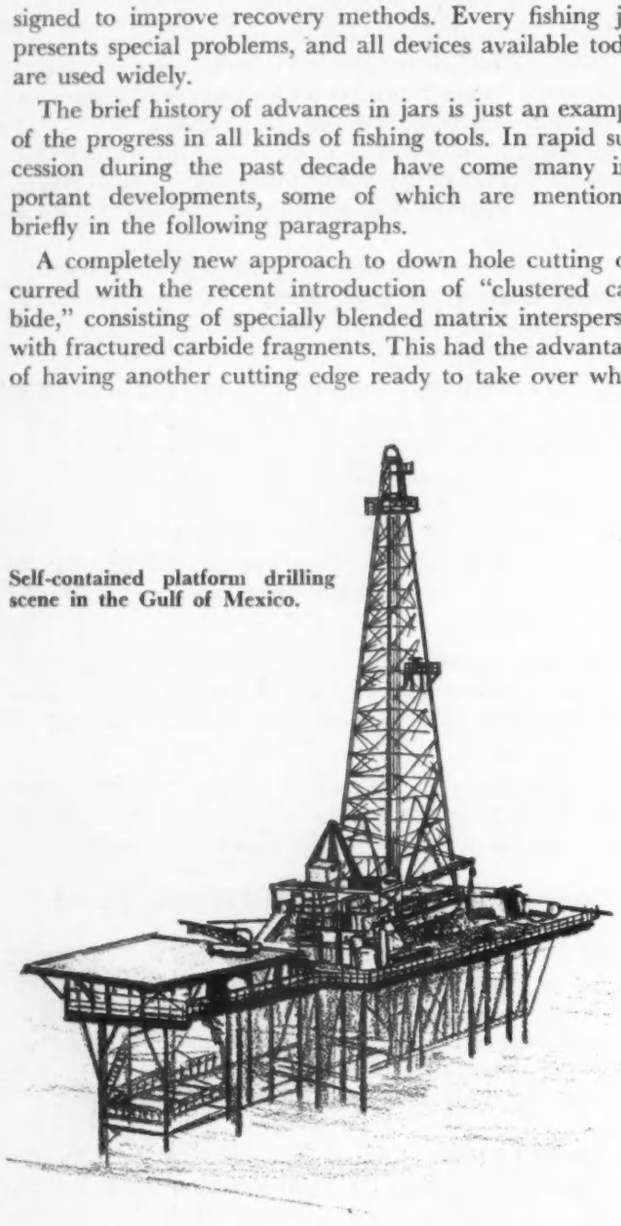
Modern jarring tools may be classified as torque jars, mechanical or spring-loaded jars, hydraulic or oil jars, and nitrogen or impact jars. Modern jars can impart extremely heavy impacts.

Recent advancements. Countless tools have been devised to recover lost materials from the hole. One tool

has made another obsolete in an endless evolution designed to improve recovery methods. Every fishing job presents special problems, and all devices available today are used widely.

The brief history of advances in jars is just an example of the progress in all kinds of fishing tools. In rapid succession during the past decade have come many important developments, some of which are mentioned briefly in the following paragraphs.

A completely new approach to down hole cutting occurred with the recent introduction of "clustered carbide," consisting of specially blended matrix interspersed with fractured carbide fragments. This had the advantage of having another cutting edge ready to take over when one started to become dull, thus reducing the number of trips required to complete the operation. Interspersed carbide has been used to speed up other downhole cutting operations, including milling operations.



Self-contained platform drilling scene in the Gulf of Mexico.

Another tool introduced in recent years to facilitate extraction of stuck pipe is string shooting. After carefully locating the condition and depth of the drill pipe and drill collars by means of an electronic indicator, a charge of primacord is fired in the hole to loosen the threaded connection so the upper portion of the pipe can be spun off and brought out of the hole.

To eliminate the need to perform all the washing over operations separately, the washover operation and the subsequent drill pipe run to secure the fish have been combined recently into a single tool known as the washover-backoff connector. The origin of backoff tools goes back to as early as 1915.

Other progress. Hydraulic pulling has been used since 1946 whenever brute force is needed to recover stuck obstructions. Such tools are essentially hydraulic jacks, with five or more pistons, and are capable of extremely hard pulling force.

A magnetic junk basket was developed in 1951 to circumvent the need to drill with previously used baskets. A 7⅜-inch O.D. magnetic basket has a lifting force of about 800 pounds, therefore is capable of lifting many objects from the hole.

DRILLING GOES TO SEA

In the industry's ever-widening search for new oil and gas fields, drilling activities have moved from land to inland marshes and lakes, and now to open ocean waters.

Since World War II, more than 2,700 wells have been drilled offshore in open waters, with over 2,400 of this number since 1954. Most are located off the Louisiana Coast in the Gulf of Mexico. A sizable number have been drilled off the Texas Coast, and others in the Gulf of Paria between Trinidad and Venezuela, the Persian Gulf in the Middle East, in the East Indies, and elsewhere.

As early as 1896, a few wells were drilled off the California coast from wooden platforms erected close to shore. Similar structures were used for lake drilling in various areas during the next 25 years.

Inland marine drilling. The forerunner of modern offshore drilling began in 1923, when development started in Lake Maracaibo in Venezuela. One of the first important steps was the development of reinforced concrete pilings in 1927. These replaced wooden piles because of excessive destruction from worms.

Meanwhile, activities spread to the marshes of southern Louisiana. By 1930, boilers and their accessories were mounted on wooden barges, similar to the pattern in use at Lake Maracaibo. This reduced rig moving and erection time, and made the use of smaller platforms feasible.

The modern-day submersible barge, which had been patented a few years before by Capt. Louis Giliasso, came into use in 1933. This was a major step forward. The entire drilling installation, including the derrick, now became portable. It no longer was necessary to assemble and dismantle rigs for every new well, for they could be moved intact.

These barges were submerged to the bottom of the lakes and marshes during drilling operations by filling bulkheads with water. They were refloated for moving by pumping the water out of the bulkheads. Drilling was conducted through a slot in one end, which also permitted the barges to back away from locations after installing production equipment.

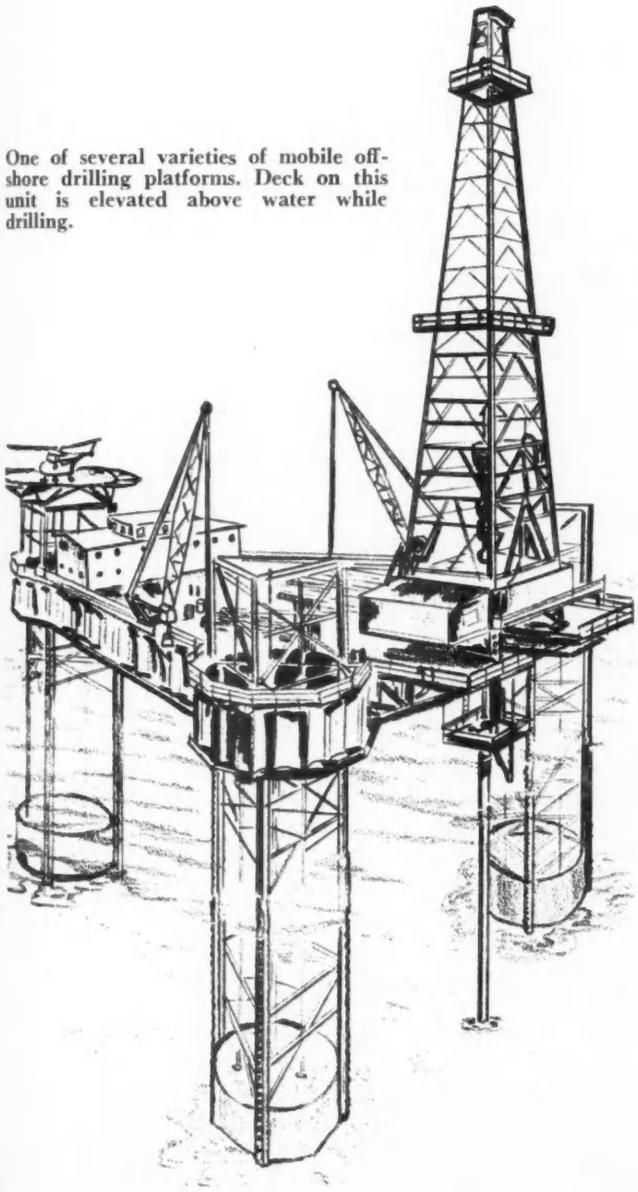
Barges of this type still are in use today in large sizes. The first submersible barge was 114 feet long, but they now are built up to 200 feet with drafts of 15 feet.

The move offshore. The first discovery in the open waters of the Gulf of Mexico took place in 1938, a short

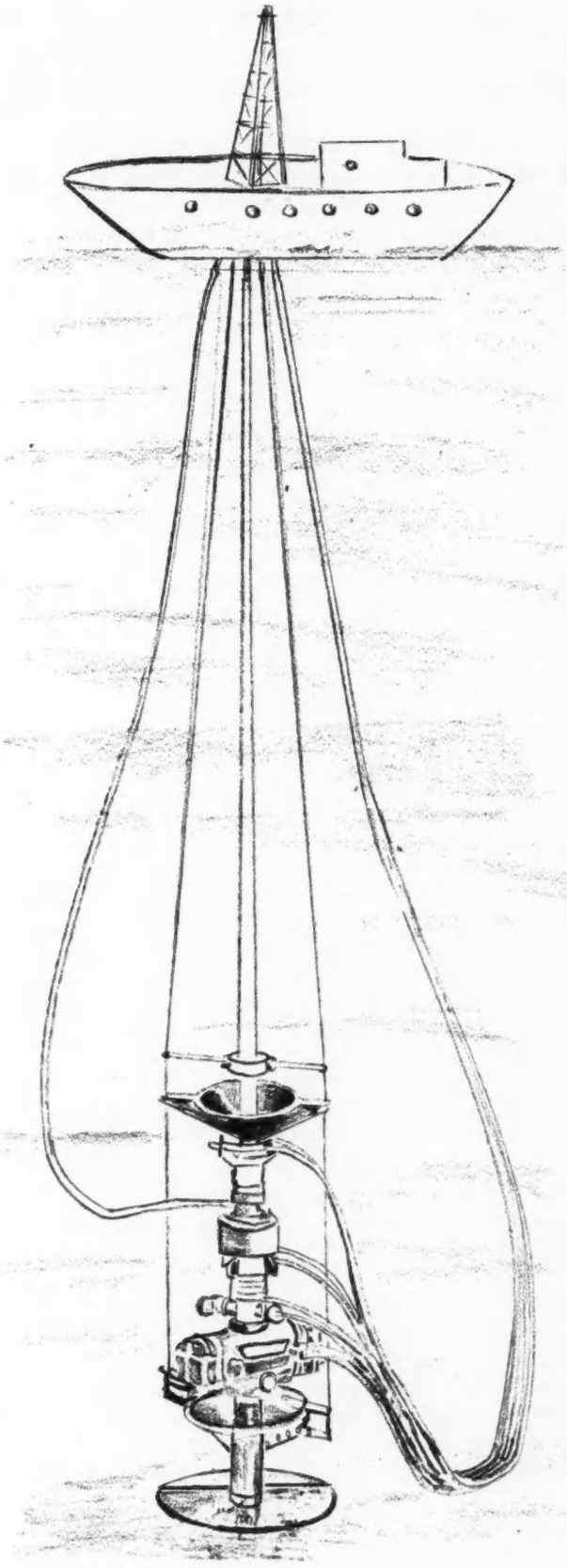
distance offshore at Cameron Parish, Louisiana. This operation, jointly owned by The Pure Oil Company and Superior Oil Company, used a 180-foot by 320-foot creosote treated timber piling.

Little additional offshore activity occurred during World War II. The next major advance was in 1946, when Magnolia Petroleum Company constructed a platform about six miles off the Louisiana coast. This marked the first time steel pilings were used for building drilling structures in the Gulf of Mexico. Steel has been used in the construction of all large structures, and most small platforms, since that time.

Offshore activity now began in earnest and on an increasing scale. Millions of acres were leased off the Louisiana and Texas shores during the next several years. By early 1957, offshore crude production was in



One of several varieties of mobile offshore drilling platforms. Deck on this unit is elevated above water while drilling.



Hookup for sub-sea drilling and coring operations places remotely controlled wellhead equipment on ocean floor.

excess of 150,000 barrels daily, and 45 fields had been found.

Offshore drilling practices. Drilling structures for offshore work have evolved into three major types, with many variations in each group. The three types are:

1. Floatable mobile units of many varieties. Some have double decks, with the lower deck or pontoon submerged on bottom for drilling. Others have decks supported by a variety of differently designed legs that rest on bottom while drilling. Some of the larger mobile units have elevating decks, and are capable of operating in 100 feet of water.

2. Minimum deck platforms with servicing tenders that house the crew, the mud system and drilling power units. The first of these units was put into service in 1947, and proved successful in lowering costs and speeding up construction as compared to larger self-contained platforms.

3. Self-contained platforms that house crews and all drilling equipment. Some of these are 400 feet in length. A number of wells may be directionally drilled from such a permanent platform. Similar structures are the man-made islands that have been used off the California coast.

So far, wells have been drilled in 112 feet of water, and more than 60 miles offshore.

In recent years, specially designed derricks for multiple well drilling have made possible the drilling of as many as six wells with only minor changes in the drilling setup. The rotary table, placed on removable deck sections, can be operated from six different sprocket positions.

Tilting derricks have proved valuable in picking up loads of 250,000 pounds during erection of platforms.

Sub-sea drilling. Latest innovation is the introduction of underwater drilling. This entirely new approach, the wellhead equipment, including blowout preventer and rotating packer device, is mounted on the ocean floor. It is connected and disconnected entirely by remote control from a drilling barge, which may be smaller and less expensive than when all this equipment is barge mounted. Guide lines permit the drilling string to re-enter the hole at any time.

The technique has been used widely for coring work at various depths in the Pacific Ocean, and now has been adapted to drilling operations.

CHAPTER IV

Detecting Presence of Oil in Hole

ONE of the principal early drawbacks to the rotary drilling system was the accompanying difficulty in detecting the presence of oil or gas, although the bit had penetrated a productive horizon. Unquestionably, many oil or gas bearing formations were drilled unknowingly.

Some were mudded off by the circulating fluid. Despite inspections of mud returns, others went undetected due to being mixed and contaminated so thoroughly during the time delay before cuttings reached the surface.

This was no problem in cable tool drilling. Periodic bailing of cuttings from the hole provided satisfactory means of detecting the presence of oil and gas, and the true depth of such showings.

Obviously, the possibility that producing formations might go unnoticed was an extremely serious drawback to rotary drilling. The only objective for drilling is to find oil or gas production. Consequently, difficulties in detecting oil or gas formations penetrated by the bit delayed any widespread acceptance of rotary drilling for many years, despite the method proving itself a more efficient hole-making device. This was especially serious in wildcat drilling, where the depth of producing formations was not known.

The rotary system no longer is handicapped by any difficulties in detecting the penetration of oil or gas bearing zones. A series of developments has overcome this drawback completely.

Major advances which solved rotary's detection problems came during the 1920s, the era when engineering came into the industry. The initial step in solving this problem was the introduction of improved rotary core barrels and better coring practices in the early 1920s. Then came drillstem testing in the mid-1920s. The greatest of all improvements, however, was the introduction of electric logging in the late 1920s. Subsequent advancements have increased the efficiency and scope of electric logging until it provides geological records superior to all others, in addition to providing a wide array of reliable information on oil, gas and water content of formations.

Subsequent improvements of these methods, together with advances in analyzing mud returns, have given rotary drilling the finest of all oil and gas detecting systems. Again, this is an example of how technological progress has made huge additional quantities of oil available. Today, many producing wells are completed in thin, lenticular formations that would have gone unnoticed in the past.

ROTARY CORING ADVANCES TO EFFICIENT STAGE

Methods of taking cores in percussion and diamond drilling were unsuitable for rotary drilling. Because of the flushing and disturbing action of the circulating fluid, attempts to apply similar coring devices to rotary drilling left only broken fragments containing little evidence of content.

Early coring tools. The first coring device especially developed for rotary drilling appeared in 1908 in Holland. It had an inner tube to protect the core from the flushing action of circulating fluid.

Many improvements on the Holland rotary core barrel were made before it was introduced in the U. S. in 1919. Up to this time, it was a common practice in the U. S. to cut slightly inwardly bent V-shaped teeth on the end of a four to six-foot piece of pipe. Run on the end of the drill pipe, it was rotated to cut a core. Weight then was applied to buckle the teeth so they would hold the sample while withdrawing the drill pipe from the hole. At best, only a few inches of sand or soft formations could be cored.

Improved coring tools. J. E. Elliott introduced an improved coring device in California in 1921. Like the Holland core barrel, it utilized an inner and outer tube, with circulation passing between them.

Continuous improvement on the Elliott coring tool led

to considerable advancement by 1925. One-piece construction made possible the replacing of worn or broken cutter heads and the interchanging of heads designed for hard or soft formations. Cutting teeth were made of alloy steel, and hard faced. A ring fitted with springs acted as a core catcher, permitting outward projection, instead of inward projection, of teeth. Thus, it became possible to take larger diameter cores. The improved core barrels also could take longer cores, up to 20 feet.

Modern conventional rotary core barrels still are composed of two major parts—the outer, or working, barrel, and the inner, or core retaining, barrel. There are two types of inner barrels—those that revolve with the outer barrel and those which do not.

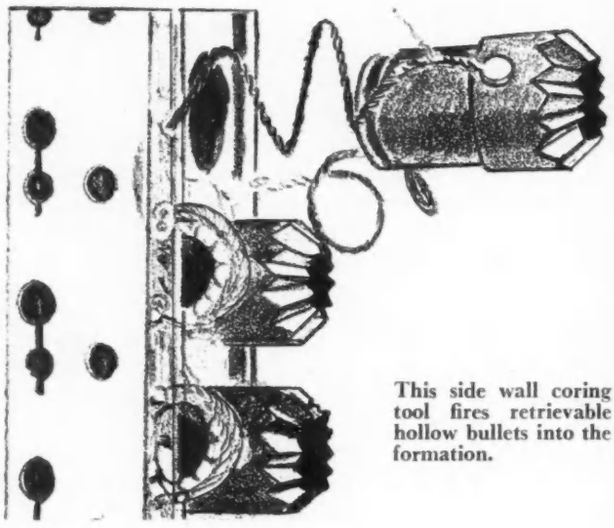
Although the modern conventional core barrel still is designed along the same principles used in the 1920s, rotary coring has undergone major improvement. Larger and better cores now can be taken in any kind of formation in far less time and with much higher core recoveries. Among other introductions are double core catchers to insure maximum core recovery.

Better core bits. Improvements in design and quality of bits have been a major factor in increasing the efficiency of rotary coring tools.

As in rotary drilling, coring initially was limited to soft formations because of the poor cutting ability of the bits. The first specially designed rotary coring bits were of the fishtail type. While a definite improvement over the saw-toothed pipe, fishtail core bits still did not have the ability to take hard formation cores.

Coring devices at left were introduced in 1925. Top center is a Holland core cutter head of 1908. Lower center shows a modern soft formation core bit. A modern diamond core bit is shown at upper right. Today's hard formation cutter head appears at right bottom.

The next step followed the pattern previously established in the development of drilling bits—the introduction of roller rock cutters similar in design to the rotary rock bit, except for a hollow center to allow passage of the core. These bits were made interchangeable with fishtail bits, affording the driller a choice, according to the type of formation to be cored.



This side wall coring tool fires retrievable hollow bullets into the formation.

Introduction of progressively harder metals has permitted constant improvement in the cutting ability of both the fishtail and rock core bits.

Advances in diamond coring. For years, it was usual in diamond bit drilling to take cores continually in various hard formation mining and tunneling operations. Although the diamond core bit was used to some extent in hard formations after the introduction of improved core barrels, it found relatively little application in the oil industry until recent years because of excessive cost.

A major step in diamond coring advancement was the introduction of mechanical means for setting the diamonds in the bit crown. This was far less expensive than the old hand setting methods.

Diamond core bits have come into wider use during the past 15 years, especially in hard formation coring. Along with increased usage has come many advancements in design, including processes which make the loss of diamonds in the hole far less likely. Many diamond bits of varying designs now are used by the oil industry.

Retractable coring tools. More technological advancements have made available retractable wireline coring tools which are run inside the drill pipe, saving the expense and delay of making one round-trip with the drill pipe each time a core is desired. Considerable time and labor are saved in deep holes.

Retractable core barrels were introduced in 1928. At first, they were used with a special fishtail bit. Later, roller rock bits and diamond bits were adapted to the method, and it became usable in hard formations.

In the earlier days, only very small diameter cores could be obtained with wireline coring tools. This was due to the small internal opening in normal tool joints.

Introduction of larger internal diameter tool joints partially overcome this handicap.

Pressure core barrels. The problem of core content alteration, resulting from the time required to bring cores to the surface and to examine them—led to the development of pressure core barrels. The first of these was tested in 1939.

These devices work on the principle of sealing the core in an inner barrel while it is still in the bottom of the hole, so gas expansion will not drive part of the oil from the core. This provides more reliable information.

Side-wall samplers. By 1940 devices were in use which made it possible to obtain samples of formations in wells through which the drilling bit already had passed. There are two types of these side wall samplers.

One is a hydraulic sampler run on the end of the drill pipe. Mud pump pressure is used to expand hollow tubes outwardly at the desired depth.

The other is a gun device, which fires into the formation hollow bullets that are attached to retrievable wire cables.

FORMATION TESTER IS IMPORTANT ADVANCEMENT

Introduction of a formation tester in 1926 by E. C. Johnston marked a further major advancement in rotary drilling. For the first time, the industry had a way to test contents and productivity of zones encountered in a drilling well, without the expense and loss of time in running and cementing casing.

Prior to the advent of the formation tester, or drillstem tester, a water shutoff had to be made each time the fluid content of a formation was tested. This could be done only by running a casing string, which had to be cemented if a layer of clay was not present a short distance above the possible producing zone. While attempts were made to recover the casing if the formation was not commercially productive, most of the casing usually was lost.

The ability to test formations through the drillstem eliminated the need for casing the hole to determine the fluid content of formations. Use of the tool spread to all parts of the world almost overnight. The ease and low cost with which formations now could be tested led to the testing of formations which formerly would have been passed up because they did not appear too promising. Thus, the discovery of many new producing fields is credited to the formation tester.

With the passing of the years, formation testing has kept pace with other technological progress of the industry. During the years, testers have been made simpler and more efficient and capable of testing under a wider range of conditions. Newer models make possible the testing of more than one zone with just one trip into the hole.

Early formation tester, which was introduced in 1926.

Recent years have seen the introduction of electrical formation testers. Formation fluids flow through gun perforations into reservoirs in the tool, where the sample is sealed for inspection. Throughout the test, electrical currents provide a complete record at the surface of pressure build-up, time required for build-up, formation shut-in pressure, and hydrostatic mud pressure.

ELECTRIC LOGGING SOLVES DETECTION PROBLEMS

The final step, which was to overcome the difficulties of detecting the presence of oil or gas in rotary drilled holes, began with the introduction of electric logging in 1929. This opened up a whole new field of investigation in which remarkable strides have been achieved with great rapidity.

As a result of this tremendous progress, modern electric well logging methods provide a vast scope of exceedingly valuable information. They provide accurate data of the presence, depth and thickness of oil or gas formations, as well as an analysis of the quantity of oil that may be produced. Addition of a series of new methods has solved early limitations, making reliable electric logs available for all types of formations and hole conditions.

Electric logging's success, coupled with advances in other phases of drilling technology, has completely overcome all original disadvantages of the rotary drilling system. Application of the rotary drilling method spread rapidly during the 1930s, becoming the most widely used means of drilling throughout the world.

Major advancements in electric logging have made it superior to all other methods for providing drilling geological records and in detecting the presence of oil, gas or water in wells. So important are the contributions of the electric log that it has become a standard or universal practice in most areas today. An inestimable amount of additional oil has been made available as a result.

Early electric logging. Conrad and Marcel Schlumberger introduced a new electromagnetic subsoil prospecting method in 1919 in which they measured the drop in potential between two electrodes inserted at the surface. Difficulties in getting sufficient depth penetrations gave the Schlumbergers the idea of using drilled holes for the subsurface measurement of the electrical properties in formations. They began to work on developing down-hole instruments to record such measurements.

The new method was field tested in France and Morocco in 1928. It first was applied to the oil industry in the Pechelbronn field in France. The only electrical property measured at this time was the specific resistance of formations.

Early experiments were highly encouraging. It soon was learned that the new instrument could measure the varying electrical resistance of different formations and

fluids in drilled holes. A great advantage was its ability to provide a continuous log in a very short time.

The technique was introduced immediately into Russia, the Netherlands Indies, Venezuela, Rumania, the U. S., and Trinidad, and thereafter its use spread rapidly.

Advances in conventional logging. A major advancement took place when the measurement of spontaneous potential of formations began in 1932.

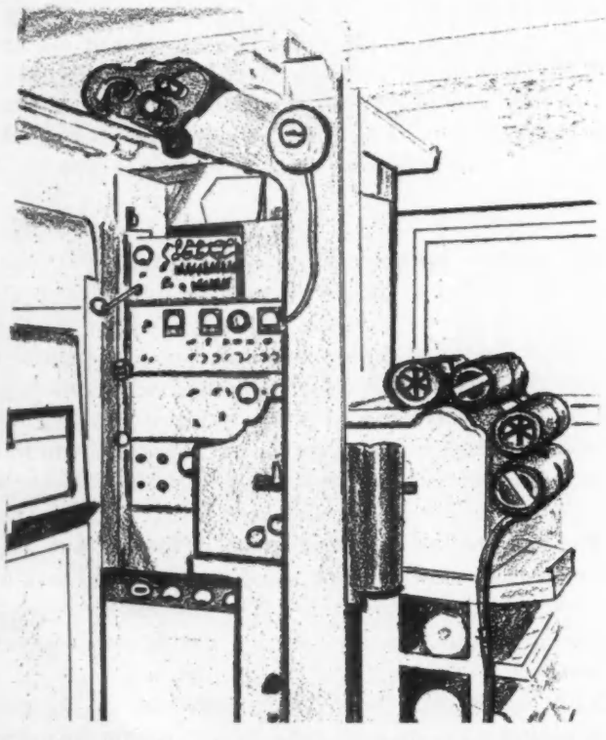
Combination of spontaneous potential measurements and formation resistivity measurements using spaced electrodes proved especially effective when used in fresh muds, formations of low to moderate resistivity and fairly thick beds.

The modern conventional electric log includes a complement of simultaneously recorded curves. These insure that no detail is missed. A wide variety of electrode configurations is used to meet the needs of various areas and conditions.

New methods are introduced. Accurate detection of economically productive strata has been improved greatly in recent years through introduction of new techniques which have overcome the shortcomings of conventional electric logging. Various methods now are available which will yield excellent logs under all kinds of conditions.

The introduction of radioactivity well logging in the late 1930s made possible the obtaining of logs through one or more strings of casing. This was accomplished by measuring the varying degrees of gamma radiation in different strata. It was particularly valuable in older oilfields, where the wells had been drilled before the introduction of electric logging.

Continual development of radioactivity logging has increased its scope greatly. In addition to recording natural radioactivity, induced radioactivity measurements are in wide use today.



Interior of modern electric logging unit includes many sensitive instruments and recorders for various operations.

These methods may be used alone or in combination with other logs to supply more complete formation data. Besides being used in cased holes, radioactivity surveys often are used in oil-base muds and salty muds.

In addition to conventional electric and radioactivity logging, a number of other new electric logging methods have been introduced since World War II. These can be classified in three main groups: focused logging, mud filtration logging and sound shock-wave logging.

A number of focused induction logging devices has been introduced. They have proved a signal advancement where beds are thin. Some of the systems operate best in oil-base muds and gas-drilled holes, while others are designed for operation in fresh water and salt saturated muds.

Several different types of mud filtration logging devices are other relatively new developments. Primarily, they provide precise measurements on location and thickness of permeable, broken formations. Several types can be used in either fresh mud or in salty mud.

Sound shock wave logs have opened an entirely new system of logging by measuring formation properties entirely distinct from electrical or radioactivity characteristics. Such records provide accurate porosity values in medium to hard formations, excellent correlation through clear exact indications of geological changes, and differentiate between water, oil and gas content.

These various new logging devices furnish the industry logs of the highest caliber, providing records superior to logs obtainable with similar methods a few years ago. They have transformed the detection of oil and gas in rotary drilled holes into an accurate science.

Whereas a few years ago it was necessary to run different types of logs individually, modern technique has made possible the running of a number of different logs simultaneously. This has reduced logging costs greatly. Due to the complexities of operating highly scientific logging equipment, service companies have developed highly trained logging crews.

VALUABLE DATA FROM MODERN MUD ANALYSIS

Modern technology, coupled with the time log or penetration rate devices, has overcome the problems which made the examination of rotary drilled cuttings of questionable value. It was not until 1939 that a continuous mud analysis system was developed. Constant improvement has developed systems that perform many useful functions, particularly on wildcat wells.

Through an accurate, continuing analysis of mud and bit cuttings, much more information is obtained than previously had been thought possible. Most systems in use today utilize automatic gas detection instruments and portable trailers to house a wide array of testing equipment.

Principal advantage of mud logging is its ability to get down-hole information, including detailed analyses of cuttings and cores, while the well is being drilled so oil and gas shows can be detected quickly.

CHAPTER V

Completion Methods

BETTER WELL completion equipment and techniques constitute still another example of how spectacular technological advances have overcome the peculiar drilling and producing problems of the petroleum industry that arise from the necessity of working far below the surface without being able to visually inspect what is happening.

Modern methods have replaced early primitive, wasteful and inefficient practices. Wells of great depth and with enormous formation pressures and temperatures are completed today under complete control. Water intrusion from upper horizons no longer causes abandonment of many producing wells. If water intrusion difficulties arise, efficient remedial methods usually make possible water shutoff. Means of keeping sand from plugging up the well have been improved greatly.

These advancements have made large additional quantities of oil available in two ways. They have made possible the completion of wells under conditions that were out of the question in earlier years. And they have been an important factor in enabling modern producing techniques to recover a larger portion of the oil contained in the reservoir.

BETTER CASING AN IMPORTANT FACTOR

Holes have been cased from the earliest days of the petroleum industry. This serves the multiple purpose of protecting the hole from caving formations and from water originating in upper formations, in addition to providing a sealed tube for the production of oil and gas.

Early casing materials. When Drake completed his historic well in 1859, most water and salt brine wells were being produced through hollow wooden casing. It was customary to split logs in half, hollow them out, then wire halves together. Cast-iron tubes were in use only to a limited degree, but Drake used this more modern method to set a 39-foot casing string.

Many wells completed immediately after Drake's discovery utilized these same primitive pipes as casing. Small diameter wrought iron pipe was in use by 1864.

Fortunately, oil and gas development in the early days was shallow and confined largely to areas where rock formations stood up. Casing was not much of a problem.

Early improvements. Light-weight, soft casing that served the early fields was found totally inadequate for deeper strings. To meet later requirements, pipe manufacturers began making better and heavier casing.

Although Bessemer steel was introduced in the U. S. in 1867, it was 20 years later before the first low-carbon steel casing was used by the oil industry. The next step was to use heavier weight pipe with longer couplings.

Until about 1925, nearly all casing in the U. S. was made by the lapweld process. Seamless casing came into wide use during the 1920s, although the steel industry developed methods of manufacturing seamless tubular goods as early as 1890.

API specifications. American Petroleum Institute issued its first specifications of oil well casing in 1924. These standards included specifications for two classes of lapwelded steel, three grades of seamless steel pipe, wrought iron pipe, and open-hearth iron pipe, and served the industry quite well at the time. But to keep abreast of rapidly changing conditions, revised specifications have been necessary from time to time.

As drilling depths increased beyond 10,000 feet, manufacturers have worked incessantly and successfully to improve the qualities of casing. By 1930, heat-treated alloy steel seamless casing was available.

There was little chance for development of improved casing during the war years of 1941-45. To meet rapidly

increasing depths since the war, casing has undergone great advancement.

In 1948, alloy steel seamless casing with minimum yields of 80,000 pounds per square inch was in use. By 1958, casing having minimum yield strengths of 140,000 to 150,000 pounds per square inch had been run as deep as 25,000 feet. Laboratory tests now are under way on casing of even higher strength.

Casing joints. As casing was improved, it became necessary to strengthen casing joints. API in 1938 adopted the round thread for casing in sizes 13⅜ inches and under. Over the years, the introduction of a wide variety of casing joints has gone a long way toward solving tensile strength and leakage problems.

But by the mid-1930s, the trend toward casing of smaller diameter and wall thickness created an urgent demand for coupling joints of much higher strength. Pipe mills introduced several designs incorporating such features as shouldered joints, upset semi-flush joints, power threads, etc.

Floating equipment. The problem of running deep casing strings was eased with the introduction of floating equipment in the 1920s. Difficulties in running casing was a serious problem up to this time. A sharp shoe still was in use at the bottom of the casing. It was thought the sharp shoe cut off any projections on the hole walls, thus making it more certain that the casing would reach bottom.

Running of casing and cementing of wells have been advanced by the development of many devices. At top left is a 1907 casing shoe. Top right is a 1923 float collar with cast iron valve. Lower left is a 1927 cement float shoe. Center bottom shows a 1927 cement float collar. A cement whirler shoe of 1929 vintage is shown at lower right.

Development of floating equipment made the running of long casing strings safe and economical. Due to the buoyancy effect they imparted in holes filled with mud, floating equipment reduced the loads imposed on hoisting equipment while running casing strings, and also lessened the loads imposed upon the pipe itself.

The first step in this direction was the introduction of the rotary hole guide shoe. Casing stuck much less frequently than with the sharp shoes used previously.

The next major advancement was the introduction by R. C. Baker in 1923 of a beveled-bottom float shoe with cast iron valve. Baker also had developed cement float shoes and cement float collars by 1927.

The next few years saw marked improvement in design and construction of this early casing floating equipment. Newer designs were free of metal or other material difficult to drill out.

Deep casing strings now could be run, and one of the major problems in reaching oil lying far beneath the earth's surface was overcome.

CEMENTING ADVANCES SOLVE WATER PROBLEM

Modern techniques have proved highly efficient in preventing intrusion of upper zone waters into producing formations. This is one of the most important of all technological advances. Numerous producing wells were ruined in the early days because of the inability to exclude shallower waters.

Early methods. Earlier wells depended almost exclusively upon the driving of the casing shoe into some upper zone, preferably clay, to obtain what was called a formation shutoff. Pioneer operators soon supplemented this method by using leather bags filled with flaxseed or other cereal in an effort to seal off the annular opening between the casing and walls of the hole.

Later practices involved the use of various types of fibrous material, such as chopped rope, cottonseed hulls and lead wool. This lead to the development of special types of mechanical packers of burlap, canvas or rubber.

Obviously, such primitive methods failed to perform the function of efficiently sealing off the intrusion of upper waters. Water intrusion continued to be an extremely serious production problem.

Early cementing methods. The first attempt to use cement as a formation sealing agent is reported to have occurred at Pico, Calif., in 1883. Burlap containers filled with cement are said to have been lowered on the sand line. However, due to difficulties, the first serious attempts at using cement did not take place until early 1900.

In 1902, F. F. Hill, Union Oil Company of California, used a special bailer to dump 50 feet of cement slurry in a California well. He then set the casing down in the cement. Some 28 days later, the cement was drilled out. Several cementing jobs were performed in this manner in 1903.

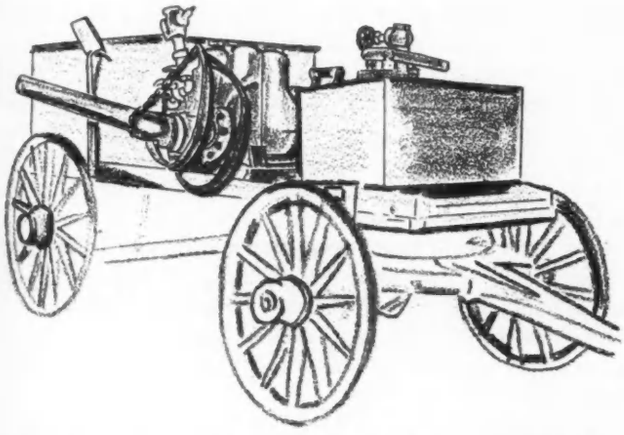
It was not until 1905 that cement was first placed in the hole through a tubing string, which was packed off near the bottom. Cement shoes to prevent the cement from entering the casing when it was lowered were devised during this period.

Mixing of cement was a back-breaking task in those days. The slurry was hand mixed in wooden mortar boxes, then hand shoveled into the dump bailer. Fortunately, only 30 to 100 sacks of cement needed to be mixed for the usual cementing job of that day.

Advent of modern methods. An extremely important stride took place with the development of the double

plug cementing process in 1910. A. A. Perkins and Edward Double invented this method, which made it possible to put large quantities of cement behind the casing. Cementing of wells came into universal use immediately.

With the introduction of the Perkins-Double cementing process, the length of time to mix cement slurries by hand was the chief limitation on the quantity of cement that could be placed in the shallow wells of that day. Portable cement mixers helped to some degree. This problem was to be overcome with the introduction in the early 1920s of the Earle Halliburton method of using synchronized pumps, the cement hopper, a jet-vacuum mixer, and a measuring line.



One of the first cementing vehicles was a horse-drawn affair.

Now, satisfactory water shutoffs behind casing strings became a practical reality. A combination of the Perkins-Double and Halliburton methods has been the standard cementing procedure since that time.

Besides making possible the fast pumping of large quantities of cement, the double plug method prevented the contamination of the cement slurry. The method encloses the cement between two plugs, one placed ahead of the cement and the other behind, or above, the cement.

The first procedure was to cement through the casing, but this was replaced by cementing through the tubing or drillstem in the 1920s. The advantage was that the cement could be placed faster than through the casing.

In the early days, cement arrived at the well in cloth sacks. Paper sacks replaced the cloth bags. Today, bulk storage cement facilities have been installed in many active areas. Unsacked cement is taken from big storage bins to the well in specially designed trailer-mounted steel tanks.

Refinements in methods. The drilling of deeper wells has made many refinements necessary in cementing techniques. More powerful surface pumping equipment, coupled with better down-hole cementing equipment, and advances in the cement itself have met all the problems of cementing higher pressure and higher temperature wells.

In addition, special cementing techniques and equipment have been developed which have widened the application of cement. Today, cement is expected to perform functions other than the shutting off of water.

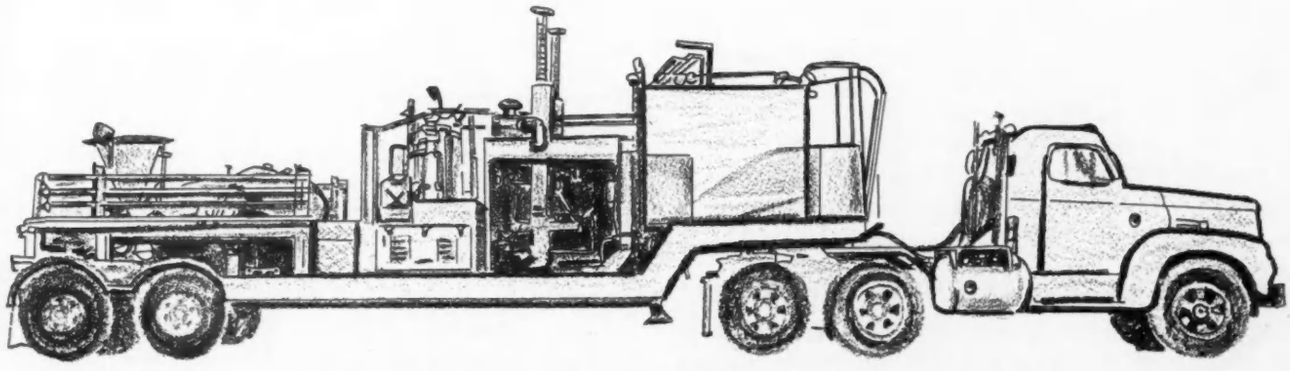
An innovation of the 1930s was the multistage cementing process. Special devices make possible the placing of cement behind the casing at two or more levels to assure complete distribution of the cement column or the cementing of formations at different depths.

Cement also is used widely today to perform various production functions. Important in this connection is the squeeze cementing method, which is discussed in the chapter on production practices (See Page 191).

Improved wall seals. The 1930s saw the accumulation of considerable data indicating many cement failures might be attributed to the mud filter cake preventing proper bonding of the cement slurry to the formations. This led to several developments which have improved the cement bond between casing and hole wall. These included washdown whirler type float shoes, chemical agents, special muds, and abrasive devices that scrape the mud from the walls.

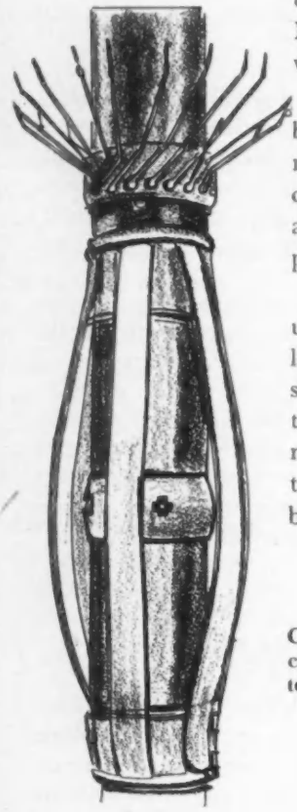
Wall scratchers were introduced in 1939. They consist of a series of wire fingers, which are welded or clamped onto the casing. The mud cake is removed when the casing is raised and lowered several times, thus exposing the hole walls to the cement slurry. Many different types of scratchers have been introduced in intervening years.

The caliper logging tool is another development that has become a valuable aid in well completion work. By measuring the diameter of the drilled hole, which varies greatly through different formations, it is possible to cal-



A 1959 trailer-mounted cementing unit has facilities for quickly mixing and placing large quantities of cement in the hole.

culate more closely the amount of cement needed to obtain a selected fill-up behind the casing. The first caliper tool was introduced by Myron M. Kinley in 1935, and was in common use by 1940.



Casing centralizers also have been helpful in getting better cementing jobs. By centering the casing in the hole at all points, an equal amount of cement is placed around the pipe.

Modern techniques involve the use of temperature devices which locate the top of the cement slurry behind the casing. Until this development, engineers had no way of determining whether the proper amount of cement had been placed behind the casing.

Casing wall scratchers and casing centralizers have helped provide better cement jobs.

Improvement of cements. The first cementing materials used by the oil industry were common portland cement. Until the 1920s, when a well had been cemented, it was necessary to wait two or three weeks for the cement to set properly. Initial efforts to overcome this long delay were unsuccessful.

This now is changed. Development of special oil well cements and quick-setting reagents has reduced the time of waiting to a few days. The first steps in this direction occurred during the early 1920s, when cement waiting time was reduced to something like five or seven days.

The following years brought the development of special cements with greater strength. Through the addition of setting agents, waiting time has been reduced further.

On the other hand, cement with slower setting time has been available for something like 20 years. This type is necessary in deep wells with high temperatures so the cement will not set before it can be pumped behind the casing. Modern slow-setting cements have quick-hardening qualities once the initial set begins.

Many special oil well cements are in use today to overcome particular problems.

ADVANCES IN SAND EXCLUSION TECHNIQUES

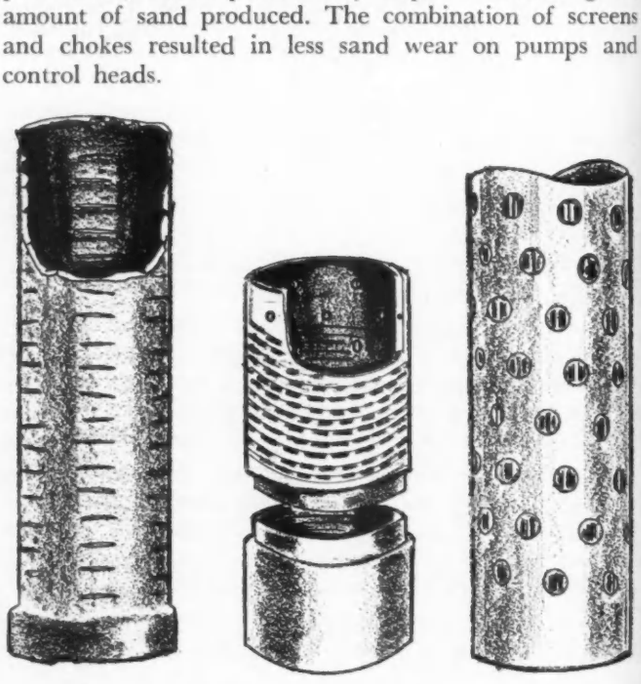
For many years, practically all wells used the open-hole completion method, in which the casing was set above the producing formation. As drilling depths increased and spread to new areas, more and more wells found production in loose sands. Vast quantities of sand often were produced with the oil.

This condition resulted in the cutting away of control valves and pump plungers. Further, sand accumulation in the bottom of the hole impeded the free entry of oil, making frequent cleaning out of wells a costly operation.

By 1900 some operators were setting the casing through the producing zone, using mechanical casing perforators to cut slots in the pipe for the entry of the oil. This operation did not prove too satisfactory, due to the unreliability of mechanical perforators to punch holes in the casing.

Screens become popular. The early years of the 20th Century saw the introduction of screen liners, which were set through the producing formation in an effort to limit sand production. A wide variety of these screens was introduced during the next few years. Important steps were the introduction of wire wrapped screens and screens fitted with slotted buttons. These proved more successful in coping with sand problems.

By 1911, flow beans, or chokes, were being used in California fields. Besides providing easy regulation of production, chokes proved very helpful in reducing the amount of sand produced. The combination of screens and chokes resulted in less sand wear on pumps and control heads.



Pipe with slotted perforations is shown at left. Center illustration shows wire-wrapped screen pipe in use in 1907. At right is section of pipe provided with screen buttons.

Despite many important improvements in screen design, sand still was a troublesome problem in many areas during the late 1920s and early 1930s. Frequently, sand would cut out the screens, making their replacement necessary. In other instances, screens would become clogged, requiring their cleaning with hydraulic washing devices or explosives. If this did not work, the screen was pulled and replaced with a new one.

Especially troublesome conditions were encountered in

completing extremely high pressure wells in the Oklahoma City field in the late 1920s and early 1930s. Huge quantities of sand were produced at high pressures. All sorts of trick methods were invoked to combat the cutting out of control equipment, including lead-lined sand separators, special expansion flow chambers, and lead-lined tanks.

Gravel packing is used. Although gravel packing long had been used in completing water wells, it was not until 1932 that an oil well was gravel packed to stop sand intrusion. Relatively few wells were packed until 1937, but during the next decade a large number of wells was gravel packed. Of the approximately 14,000 wells completed in California between 1938 and 1948, some 2,100, or 15 percent, were gravel packed.

The first method of packing was to utilize a circulating fluid to pump gravel into the annulus between a screen or slotted liner and the well bore. Within a few years, prepacked liners, with the gravel between the liner and outer perforated sheath, made their appearance.

Chemical sand consolidation. A forward step in the exclusion of sand from well bores was the introduction of chemical plastics which bond together loose sand grains. This prevents their movement into the well bore with production fluids.

Plastics used in such work are thermo-setting and have the property of preferentially wetting the sand grains. Some of the plastics in use contain additives which shrink upon setting. Others flush the excess plastic from the sand.

The first method of utilizing sand control chemicals left some plastic in the casing below a drillable retainer and tail pipe. A later development employed a retrievable squeeze tool, which permitted displacement of the entire plastic load. Further developments have made it possible to perform such work through production packers without moving the tubing, eliminating the necessity of a workover unit, or through retrievable tubing cementing packers.

GUN PERFORATING OPENS NEW ERA

Introduction of gun perforating must be classified as one of the major technological steps in the industry's first 100 years. With stage cementing, which followed gun perforation almost immediately, well completion techniques have been revolutionized.

Gun perforation made it possible to drill to the desired depth, case to bottom, and subsequently open the casing selectively at different depths for testing. This provided the industry with its present highly flexible and selective completion practices. The ability to precisely control the amount of formation to be opened for production proved highly valuable in the regulation of gas-oil ratios, formation water and formation sand.

Gun perforating also made possible the testing and retesting of different zones in a single well, and led to great improvement in well remedial procedures. Formations behind casing in old wells now could be opened for production.

Bullet perforation advances. Although the idea of gun perforating casing dates from about 1900, the first practical application did not occur until 1932, when W. G. Lane and W. T. Wells introduced an improved gun perforator. It was an immediate success, and the practice of gun perforating the casing came into wide use within a few years.

Gun perforating equipment today uses the same general principles as when introduced in 1932. However, tremendous progress has greatly improved the efficiency and reliability of modern guns. New and different steels in gun chambers and bullets have been necessary because of better steels used in casing and the desire for greater penetration.

Today, a wide variety of bullet guns is available. These may be fired selectively or simultaneously. Guns in a wide variety of sizes are available, including units which can be run in the smallest size casing or even in tubing.

Shaped charge perforating. The shaped charge perforator with greater penetration characteristics has been available since 1946. This was an outgrowth of the bazooka anti-tank gun developed during World War II.

In 1947 and 1948, new tools utilizing shaped charges for use in open-hole completions were made available to the industry.

Prior to the universal adoption of gun and shaped charge perforating techniques, attempts to make upper horizons available in a single casing string consisted of using acid-soluble and drillable pipe sections. Set opposite upper producing zones, they provided a means of easily and efficiently opening them up for production at later dates. This practice came into considerable use during the late 1930s.

Bullet type gun perforator at left and a shaped charge perforating tool at right.

Fewer casing strings. For many years, it was considered essential to protect every oil zone with a separate casing string. Sometimes four, five or even six strings of casing were run in a single well. This was extremely costly, and also delayed drilling operations.

With the introduction of gun and shaped charge perforating, better pipe, advanced mud techniques, and improved cementing methods, it became possible to use

fewer casing strings. Today, it is a common practice to use only a short surface string and a single production string, even on deep wells.

USE OF MULTIPLE-ZONE COMPLETIONS INCREASES

Dual completion of wells, in which two zones are produced simultaneously, received considerable impetus during World War II because of the shortage of steel. The method continued to be attractive after the war because of increased drilling costs and limited producing allowables.

However, it was not until about 1953 or 1954 that appropriate surface and sub-surface equipment made large-scale use of dual completions possible. In the first arrangements, both the tubing and the annulus between the casing were utilized for producing the two zones without the fluids commingling. Within a short time, two parallel tubing strings came into use.

Improved packers have been an important factor which has permitted wide use of dual completions. This includes packers which may be run on either wire line or tubing strings, and retrievable type packers run on the tubing string. Various wellhead assemblies have been introduced to suspend the tubing strings.

By 1955, permanent-type dual completions were being used to gain advantages of wire-line workovers without pipe-handling equipment. A wire line retrievable tubing string is set through the upper zone in this operation.

The first triple completions were made in the mid-1950s, and the first quadruple completion came in 1958.

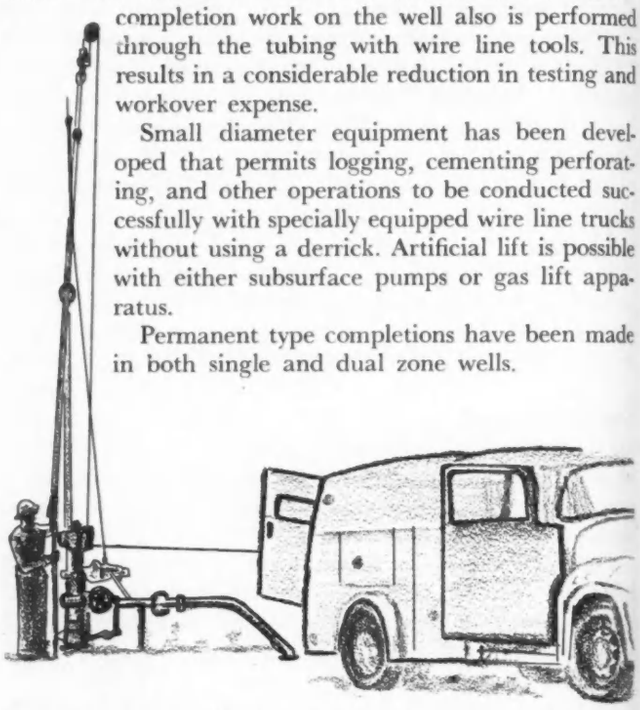
PERMANENT-TYPE COMPLETIONS A NEW METHOD

The first permanent-type well completion took place in 1950. In the next five years, an estimated 2,000 Texas and Louisiana wells were completed in this fashion,

The drilling rig is moved as soon as the tubing string and other subsurface equipment are installed, leaving the perforating, testing and bringing in of the well to be done with wire line units. All future remedial and recompletion work on the well also is performed through the tubing with wire line tools. This results in a considerable reduction in testing and workover expense.

Small diameter equipment has been developed that permits logging, cementing perforating, and other operations to be conducted successfully with specially equipped wire line trucks without using a derrick. Artificial lift is possible with either subsurface pumps or gas lift apparatus.

Permanent type completions have been made in both single and dual zone wells.



Specially equipped wire line trucks perform all completion and remedial work on permanently completed wells.

CHAPTER VI

Production Operations

EARLY days of the petroleum industry were an era of great production waste. Oil belonged to those who captured it at the surface. Everyone produced wells as rapidly as possible so neighbors would not capture it. There was no demand for gasoline and other light ends. Gas was a nuisance, both as a product and in the production of oil. The economic effects of such methods has been discussed in Chapter 1.

It now is known such practices wasted the natural gas that accompanies oil and dissipated the energy which produces oil, causing early intrusion of water to ruin wells. Consequently, only a small portion of the oil contained in a reservoir was produced. Wells had a very short producing life.

Modern technology has erased such wasteful practices. Far more—as much as two or three times more—oil contained in a reservoir is recovered today. Fields are operated which would have been abandoned a quarter of a century ago because of inefficient methods then in use. Depleted fields are made to give up a second crop that often amounts to millions of barrels of additional oil.

The engineering or scientific approach to oil field production did not begin until the late 1920s. At that time, many investigations were initiated on extraction of oil and gas by natural flow, gas lift, repressuring and waterflooding. At the same time, studies began that were to improve producing equipment greatly. These investigations have led to the development of two specialized branches of oil technology: applied reservoir engineering and applied production engineering.

MODERN RESERVOIR CONCEPTS INCREASE YIELD

The fundamental concept governing modern oil production practices is to produce oil with the smallest possible amounts of gas and water associated with it. This concept is based on the knowledge that excessive production of water and gas leads to an unnecessarily rapid decline in formation pressure which will increase lifting costs and cause lower ultimate recoveries.

The practical application of this modern concept has come to involve many complex, highly technical phases. Initial studies are made to decide optimum development and operating programs. Studies are continued through much of the life of a field so it can be produced in accordance with ever-changing conditions brought about by the removal of oil, gas and water fluids.

The gas concept. The importance of reservoir gas in solution to oil recoveries was suggested by a Mr. Briggs in 1865. John F. Carrl, of the Pennsylvania Geological Survey, elaborated upon it in 1880. Little recognition was given these early statements. Producers continued to flow wells to the limit of capacity. No effort was made to conserve gas.

One early activity of the U.S. Bureau of Mines, after it was organized in 1910, was a series of surveys on oil field waste. In 1913, L. G. Huntley stated each cubic foot of gas should be made to produce its full quota of oil. Huntley said failure to do so affected ultimate recoveries.

J. O. Lewis, another Bureau of Mines engineer, in 1916 pointed out that dissipation of gas energy caused premature flooding of sands, and, at the same time, presented a clear recognition of the important function of gas.

In a notable paper before the American Petroleum Institute in 1925, Henry L. Doherty said conservation of reservoir gas would greatly increase the amount of oil recovered. Doherty was responsible for studies by C. E. Beecher and I. P. Parkhurst which gave a clear understanding of the nature of the gas-oil solution. Beecher and Parkhurst in 1926 pointed out the influence of capillary action, and pointed out that if this increase in

surface tension could be prevented during production, a greater amount of oil would be recovered.

General acceptance of the importance of gas in the production of oil followed a 1927 report of the API Gas Conservation Committee, under the chairmanship of E. W. Marland. The committee gathered, collated and reported on all available information, and in 1929 the Bureau of Mines and API jointly published a more up-to-date re-evaluation of the material collected by Marland's committee.

Connate water influence. The next important step in reservoir engineering was the recognition of the presence and importance of connate or interstitial water.

In discussing capillary action in 1915, C. W. Washburne came close to discovering the existence of interstitial water. The Russians, N. T. Lindtrop and V. N. Nikilaeff, presented a paper before the American Association of Petroleum Geologists in 1929 in which they reported laboratory experiments indicated 18.2 percent of the pore space was filled with connate water. Lindtrop and Nikolaeff concluded that this meant the recovery of oil was greater than previously supposed and it was necessary to lower estimates of additional oil recovery possibilities in many fields.

O. L. Brace, in another AAPG paper in 1934, gave the first definite information regarding the existence of interstitial water when he reported core studies showed connate water comprised 16 percent of the fluid.

A. D. Garrison in 1934 presented more information on the physical condition of oil-water equilibrium in reservoirs. In 1938, R. J. Schilthuis, Humble Oil & Refining Company, suggested that reservoir rocks were completely wet by connate water and did not directly contact either oil or gas. Schilthuis concluded that oil and gas existed in the larger and interconnected pore spaces, while connate water filled the smaller crevices and capillaries.

Control of reservoirs. From these and many other early works on petroleum reservoir engineering have come advances which led to today's efficient reservoir engineering procedures and practices.

Modern practices. Technologists began classifying fields according to the dominant drive which expels the oil from a reservoir. In a very short time, it was recognized that dissolved gas drives, gas cap drives and water drives had significant individual characteristics, and that intelligent programs differed for the three types.

As reservoir engineering was applied with increasing intelligence, it came into wider practice. It was acknowledged that conservation of the native energy of a reservoir was the keystone governing oil recovery. Gas and water were recognized as the reservoir media which furnished this energy. The state regulation of oil production rates, described in Chapter 1, greatly assisted engineers in getting the industry to accept these views. Regulation of production on an engineering basis did not become possible until the institution of state enforced proration systems. Slower producing rates prevent slippage or bypassing of gas and water energy, increasing the recovery of oil.

Experience soon demonstrated that best production results were obtained if the output of each pool were adjusted to the field's most efficient rate. Engineering rapidly developed until this criterion could be utilized broadly and effectively.

With these engineering developments, the underground waste of oil came to an end in most fields. In its place came the age of conservation and scientific recovery. This development, together with allied phases, is largely responsible for the higher oil recovery achieved today as compared with earlier years.

Intensive laboratory and mathematical studies of the physical principles involved in fluid movement now are well established. However, since no two oil reservoirs are exactly alike, each must be studied individually to determine the most effective producing methods.

Influence of well density. Shortly after reservoir engineering came into prominence during the 1930s, it was recognized that an excessive number of wells constituted an obstacle to efficient control, prevented the fullest utilization of reservoir pressure, and did not aid ultimate recoveries. In addition, of course, the drilling of an excessive number of wells was an economic waste. As costs increased in following years, they became more and more important.

As a result, the last 25 years have seen an increasing tendency for the industry to adopt wider and wider well spacing. Whereas, at the turn of the century, wells were drilled as close together as was possible in many fields, 10-acre well spacing had been universally adopted during the 1920s as a purely economic necessity.

The industry began to drill oil wells on 20- and 40-acre spacing during the 1920s, particularly where high pressures existed. The general technical opinion today is that well spacing has no great effect on ultimate recovery.

Nevertheless, well densities in many areas, especially in the U. S., have remained comparatively high. In a large part, this is due to individual private ownership of mineral rights. The number of wells drilled, for the most part, still seems to be mainly an economic decision, depending upon the probable per acre recovery and the price of crude oil.

Much wider well spacing patterns are used outside the U. S., where individual mineral ownership does not exist. In some of the Middle East fields, two-mile spacing has been used for years in porous limestone reservoirs, and recoveries have been very high.

However, as the industry enters its second century, much thought is being given to the adoption of wider well spacing by U. S. engineers.

UNITIZATION PROGRESSES IN THE U. S.

The idea of unitizing operations has been the subject of much discussion in the U. S., and has increased in use over the years. This is due to the difficulties which have arisen because of individual private ownership of mineral rights—which often force operators to drill an

excessive number of wells—or prevent the use of the most optimum producing methods.

Henry L. Doherty aggressively advocated the unitization of oil leases during the 1920s. The API's Division of Production devoted the larger part of its program to unitization at the annual meeting in 1931. Before adjournment, the Institute's board of directors adopted a resolution recognizing the merits of unitization.

Many excellent papers and articles on the legal, technical and economic aspects of unitization have appeared in U. S. publications since the late 1920s.

Today, there are many excellent examples of unitization in the U. S. It generally is recognized that this is the most desirable type of operation from the standpoint of economics and reservoir control. Many costs can be reduced materially, and recoveries can be increased substantially.

Despite its numerous advantages, unitization is difficult to obtain in the U. S. because all the various mineral and royalty owners must agree to its adoption, except in the State of Oklahoma, which has passed a law providing for unitization if 80 percent of the owners agree. Consequently, most U. S. fields still are developed on a non-unit basis. However, many fields have been unitized, and they have demonstrated unitization is a most efficient method of producing oil.

PRESSURE MAINTENANCE BOOSTS RECOVERIES

Evidence that conservation of gas and proper utilization of reservoir energy is desirable economically and a technical necessity to higher ultimate recoveries has led to the adoption of pressure maintenance practices. This differs from repressuring in that it is started early in the life of a field as compared to later when a partially depleted stage has been reached. The idea is to maintain reservoir pressure near its original level as long as possible by injecting gas or water.

A program of this nature requires that the entire producing area be unitized so it can be operated as a single unit.

The first gas pressure maintenance operations in connection with flush production were commenced in 1926 by Marland Oil Company (now Continental Oil Company) at Seal Beach, Calif. Pressures up to 1,800 pounds were used to prevent edge-water encroachment.

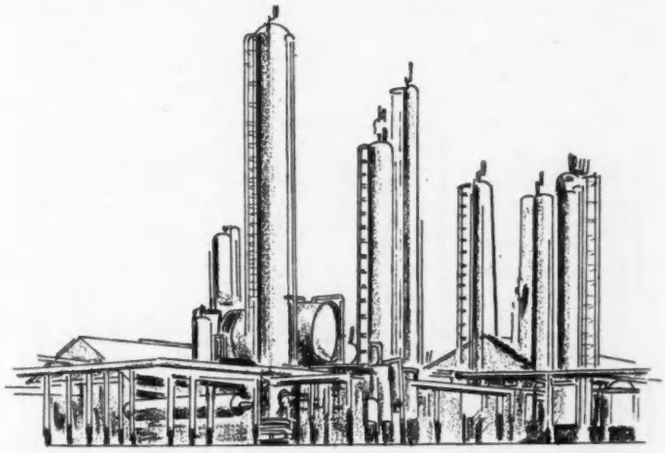
The next high pressure injection operation was in the Sugar Land, Texas, field. This program was started in 1930. It proved extremely successful in maintaining the flowing life of the field and in increasing oil recovery. A project at Sulphur, La., used working pressures in excess of 2,000 pounds in the early 1930s. In 1936, cycling operations began in distillate producing fields. Cycling operations are discussed separately in subsequent paragraphs.

Since the mid-1930s, numerous gas pressure maintenance projects have been installed in both the U. S. and other countries. Success of the program has been outstanding in practically all cases.

Pressure maintenance by water. In water drive fields, salt water has been injected into producing formations to maintain pressures. Such operations constitute a combination of salt water disposal and pressure maintenance.

Outstanding among projects utilizing salt water disposal to maintain reservoir pressure is the East Texas field. An experimental well drilled in 1936 west of oil productive limits demonstrated the feasibility of returning salt water to the producing formation. However, it was 1938 before the first salt water disposal well was put in operation. Thereafter, the number of salt water wells increased steadily.

Meanwhile, pressures were falling, and engineers were warning that tremendous losses in oil production would be suffered unless the reservoir pressure was controlled. This led to the formation of a field-wide salt water injection program in 1942. Besides serving as an efficient salt water disposal program, it has been possible to maintain reservoir pressure above the point at which gas comes out of solution.



Modern cycling plants make maximum recoveries possible in distillate producing fields by maintaining formation pressures through the return of dry gas to the reservoir.

Some authorities have estimated that more than 600 million barrels of additional oil will be recovered from the field as a result. Additional information on the East Texas salt water disposal program will be found in the portion of this chapter which discusses salt water disposal.

The first pressure maintenance by injection of extraneous water occurred in early 1943 in the Midway, Arkansas, field. The field's oil production was increased from 5,600 barrels daily in the spring of 1943 to 7,500 barrels per day in mid-1945 without any loss in reservoir pressure. A number of such projects has been installed since 1943.

Cycling in distillate fields. As drilling penetrated to greater depths, a new type of petroleum accumulation was discovered. Due to higher pressures and temperatures, petroleum was found in a gaseous form. The forerunner of a large number of these distillate fields was the Big Lake, Texas, field, developed in the early 1930s.

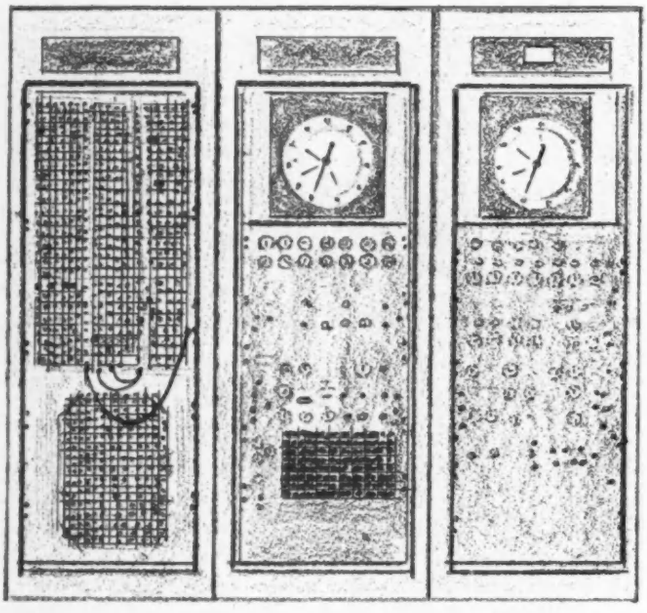
It was necessary in these fields that reservoir pressure be maintained above the point at which condensation would take place to avoid serious underground loss. A

variation of pressure maintenance came into existence, known as recycling or cycling, in which wet gas is stripped of liquid hydrocarbons before being returned to the producing formations.

The first cycling plant was constructed in the Agua Dulce, Texas, field in early 1936. Late in the same year a plant at Tepetate, La., used 3,700-pound injection pressures. During the next five years, 31 of these high-pressure processing plants were built.

MEANS OF STUDYING RESERVOIRS DEVELOPED

The tremendous amount of attention devoted to reservoir engineering during the last 25 years has resulted in the development of tools which assist the engineer in studying formation conditions and their possible reaction to different producing techniques.



Development of a wide range of reservoir engineering instruments has proved exceedingly helpful in predicting future production performance.

Pressure bombs. An important instrument in all reservoir engineering work is the bottom-hole pressure gage, or bomb.

Although various methods and instruments for determining reservoir pressures were known before 1930, it was not until that year that a bottom-hole pressure gage was marketed which fitted the special requirements of the oil industry. This was the Amerada bottom-hole pressure bomb.

With the development of this instrument and improvements made in subsequent years, engineers could make quick systematic measurements of bottom-hole pressure.

With U. S. output restricted, bottom-hole pressure bombs came into use in the 1930s in determining the potential production of wells. This was a major advancement over the previous open-flow test methods. Bottom-hole pressure bombs also were used in determining desirable flow rates and reaction of formations to different producing methods.

Other apparatus soon appeared which provided means of measuring flow velocities in wells, in checking temperature, in determining the physical properties of gas, and numerous other reservoir factors.

Reservoir models helpful. Laboratory reservoir models, on which various experiments may be conducted under different assumed conditions, were introduced in the early 1930s. These have proved helpful in providing a better understanding of reservoir mechanics and in determining optimum producing conditions for different fields.

Such models first were used in studying water-flood operations, but their applications soon spread to other work. Several advanced types have been developed during the intervening years, and it now is possible to duplicate a variety of reservoir conditions. Given favorable conditions, modern electrical analyzers can be useful in predicting reservoir performance under a wide range of conditions.

The mid-1950s found the industry successfully applying electronic computers to reservoir studies. Their speed in performing intricate mathematical calculations have proved most beneficial. Efficient specially designed reservoir analyzers also had been developed.

IMPROVED MECHANICAL CONSERVATION METHOD

With widespread recognition of the importance of solution gas in gas energized fields, mechanical means have been developed which assist in producing more oil per cubic foot of gas. In the U. S., such techniques also have played a significant role in restriction of production to state imposed limits. At the same time, as markets for natural gas expanded at amazing rates in the U. S., much progress has been made in the surface conservation of both oil and gas.

Tubing use becomes widespread. For many years, it was customary to flow wells through the casing string. Tubing was used only when it was necessary to resort to artificial lift. This resulted in extensive waste of gas. Dissipation of the gas energy in reservoirs led to lower oil recoveries.

Recognition during the late 1920s of the importance of natural gas in obtaining maximum oil recovery has led to the universal use of tubing. This became increasingly necessary as deeper drilling discovered fields with larger and larger gas content.

Widespread use of tubing in flowing wells, especially where natural gas is the principal propulsive agent, constitutes one of the most important forward steps in oil and gas conservation. Less gas is required to flow oil through a small diameter tube than a large one. This practice, therefore, prolonged the natural flowing life of wells, and increased oil recoveries.

It soon was realized that tubing was especially beneficial when well production was limited under state proration schedules. In addition, tubing was found to provide more flexible production control and to afford a means of controlling wells if troublesome conditions

Modern dual Christmas tree assemblies provide adequate control for producing from two different formations. Wellhead equipment also has been developed for producing three and four zones from one well.

arose. In particular were higher flow efficiencies attained in the case of higher pressures, which were becoming increasingly common as drilling reached deeper depths. Recognition of these advantages caused some of the state oil and gas regulatory agencies to require the use of tubing.

Until after the mid-1920s, the use of tubing in flowing wells was limited primarily to California fields. The principal use up to that time was to reduce the volume of sand produced with the oil. California engineers were quick to realize low gas-oil ratios were being obtained through the use of tubing, and this recognition helped promote the idea of using tubing in flowing wells.

The first tubing designed especially for the oil industry was introduced during the 1860s by John Eaton. Improvements in the quality and design of tubing since that time have been significant. Better metallurgical and manufacturing processes have continually improved the quality of tubing, and repairs have become less and less frequent.

The quality of tubing heads and auxiliary equipment has kept pace with advances in tubing. Better tubing catchers have been developed. Improved packers have made tubing casing seals more efficient and easy to obtain.

Development of methods for installing tubing in high pressure wells has contributed to its use. The method had its inception in 1928 in the gas fields of northern Louisiana. Subsequent improvements have made it possible to run tubing into the hole against the highest pressures encountered today.

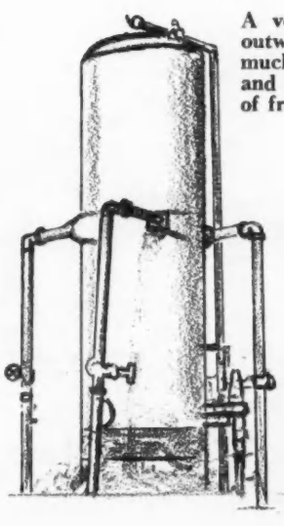
Better wellhead controls. The first U. S. flowing well was completed in 1861 at Oil Creek, Penn. However, the only semblance of wellhead controls for several years afterwards was a simple cast-iron valve or gate, used to close the well whenever tanks were filled.

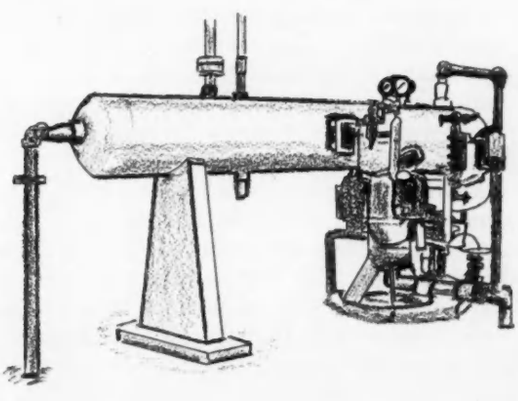
As more flowing wells with greater pressures were completed, particularly after the turn of the century, well control problems mounted. Many wild wells occurred during this period. Standard cast-iron valves were replaced in the early 1920s by higher pressure cast steel valves and, later, by forged steel valves.

The growing need to more efficiently conserve oil and gas resulted in rapid development of improved well control equipment during the 1920s. In this period, complete factory assembled Christmas trees were put on the market. They included improved tubing suspension devices, flanges, control gates, chokes, pressure gages, and other features.

Introduction of flow beans. An important step in the regulation of production was the introduction of flow beans, or chokes. There are records of flow beans being used in California wells as early as 1911, primarily to reduce the production of sand. As with tubing, engineers soon recognized that the back-pressure exerted by chokes reduced gas-oil ratios. Chokes also provided an easily adjustable means of regulating production. This became important with the growth of proration in the late 1920s and 1930s. Consequently, chokes came into wide use during that period.

During this period, bottom-hole choking of wells came into use to eliminate surface freezing caused by gas expansion on the downstream side of surface chokes. Early



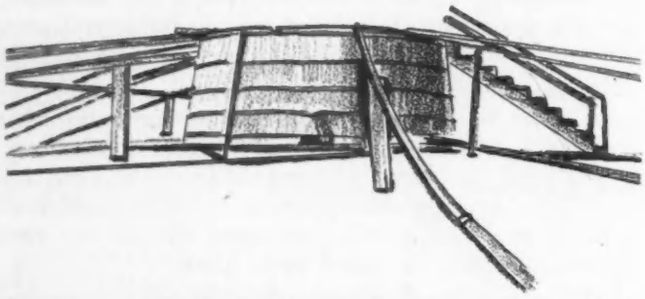


A vertical separator of 1927 vintage, at left, has a similar outward appearance to modern units. However, efficiencies are much greater today. The modern three-phase horizontal oil and gas separator, at right, also has a water leg for removal of free water.

installations had the serious disadvantage of having fixed orifices.

To change flow rates, it was necessary to shut in the well and withdraw the device from the hole. This led to the development of removable subsurface regulators in the early 1940s.

Separators important step. A primitive form of gas trap was used as early as 1865. However, it was used to get rid of the gas, rather than to conserve it. This early



Heavy losses occurred in the early days when groups of wells were produced into open-top wooden tanks.

form of a gas trap was merely a barrel placed on top of an oil tank. The gas escaped through the top of the barrel, while the oil flowed through a U-tube into the tank.

The forerunner of modern oil and gas separators was introduced around 1912. However, most wells still produced directly into stock tanks until the importance of conserving natural gas was recognized in the 1920s. With increased markets for natural gas, the importance of conserving gas increased manifold. The use of gas separators became universal in the late 1920s.

Modern oil and gas separators allow high recoveries of the gas that accompanies oil production. They have been developed and improved through a long series of advancements.

Over the years, separator working pressures have been increased to provide efficient operations in high pressure fields. This led to the introduction of multiple-stage separation during the late 1920s and early 1930s.

Tank losses reduced. Nowhere was waste more flagrant than in the unusually primitive storage methods used in the early days. Modern vapor-proof type steel tanks were yet to appear.

Oil flowed through wooden troughs into crudely built wooden boxes or into earthen pits. Seepage losses were appreciable. Vertical wooden tanks with tapered staves, held together by flat metal hoops, replaced wooden boxes. The latter type still was open roofed, and the oil content was subject to weathering.

Even in the very earliest days of the industry, heavy iron plate tanks were available, and used by some of the more progressive producers. However, they were not widely accepted. As late as 1915 many wooden tanks still were in use in U. S. oil fields. And even today they are used in some fields to overcome the problem of corrosion due to gas containing sulfur.

Welded tanks were available as early as 1915, and within a few years steel welded tanks grew in popularity. First use of such tanks was for pipe line and refinery storage, but smaller oil field tanks of this type followed soon thereafter. Constant improvements have made tanks vapor-tight, and today they are equipped with vapor saving systems.

Tank vapor saving systems. Evaporation of the lighter and more volatile crude oil ends constituted one of the most insidious losses in the petroleum industry. Attention was called to this serious loss in a complete survey made by J. H. Wiggins, of the U. S. Bureau of Mines, in 1920 and 1921. Wiggins found that many of the tanks in use at that time were not even rain tight.

More and more attention was given this important phase as the idea of conservation spread during the late 1920s. Wiggins and Ludwig Schmidt, another Bureau of Mines engineer, were especially active in promoting the idea of curtailing evaporation losses. They pointed out the terrific financial loss resulting from evaporation of light ends and reduction in gravity.

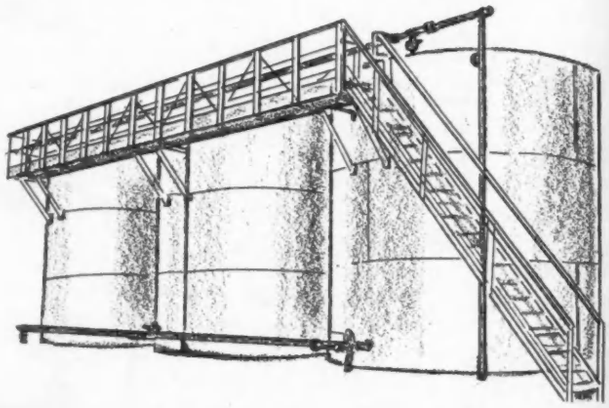
These studies led engineers to realize that evaporation losses at lease tank batteries could be virtually eliminated. Tanks were operated under pressure. Less and less surface was exposed for vaporization. Temperatures were reduced through the use of heat-resisting paints and insulation. Agitation was reduced by the properly designed flow inlets.

Along with these steps came more elaborate vapor saving systems and vapor recovery systems. In addition, there came the development of floating and breather roofs for use on larger tanks. The introduction of pressure gaging and thiefing locks made it possible to gage a tank without the loss of any tank vapors. These devices were in use by 1940, at which time several devices for indicating the height of oil in tanks were on the market.

ROD PUMPING METHODS PROGRESS

The pumping rod method of lifting oil with a walking beam has been used since the beginning of the industry in 1859. Such methods are known to have been used by the Egyptians to draw water as early as 500 A.D.

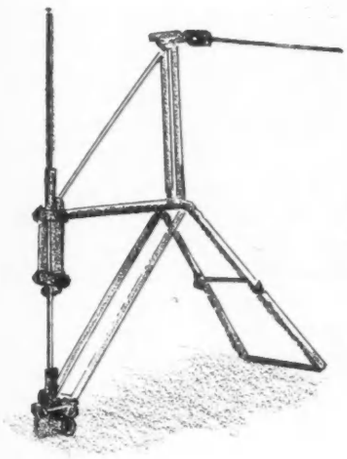
The modern sucker rod pumping system still is com-



Welded steel stock tanks give dependable service with a minimum of care and maintenance, and also reduce evaporation losses.

posed of the same four principal parts: pump, sucker rod string, pumping unit, and prime mover. However, tremendous progress has been made in the refinement, design and application of each of these component parts. As wells increased in depth, higher quality rods and pumps were designed to meet the heavier loads. In addition, engineering principles have been applied through continuous studies of pumping problems.

In the late 1920s, this lifting method was limited to depths of about 5,000 feet. Vast improvement has made



A 1921 pumping jack. It weighed only 235 pounds.

it possible to rod lift oil from depths of more than 12,000 feet today.

Advances in sucker rods. The earliest form of rod pumping used by the oil industry consisted of wooden rods fitted together with iron straps.

Solid steel rods of either ½- or ¾-inch diameter were in use during the 1890s. Still, the manufacture of sucker rods had far to go before rods reached their high standards of today. In 1927, API established standards for sucker rod joints. Each manufacturer previously had his own thread design, and different makes of rods were not interchangeable.

Wells in the Greater Seminole area of Oklahoma were going on the pump in the late 1920s. Pumping equipment was operated to the limit of its capacity. Producers demanded better sucker rods, out of which came improved sucker rod steels and a general increase in the size of rods commonly used.

The late 1920s also saw a demand for rods that would operate efficiently in the corrosive oil produced at Smackover, Ark. During the folowing years, much attention was given to sucker rod corrosion problems. In the mid-1930s, manufacturers began normalizing the sucker rod from end to end. Various alloy steels soon proved their superiority where corrosion was a factor.

Constant refinements in sucker rods have taken place since the early 1930s. Today, a variety of sucker rods is manufactured to meet the needs of particular field conditions.

Improved pumps. Non-flowing wells were pumped with piston pumps until the 1920s. These consisted of hollow steel working barrels, fitted with leather cups.

A new type of plunger pump made its appearance in the early 1920s. The sealing effect was obtained by tightly fitting a polished steel plunger into the liner of the pump body. These pumps included short liners, which could be replaced easily when operation was impaired by wear. Devices were available for pulling the standing valve without pulling the tubing string.

Other versions of the plunger pump were developed during the next few years. Among these were some models which combined the use of cups with plungers.

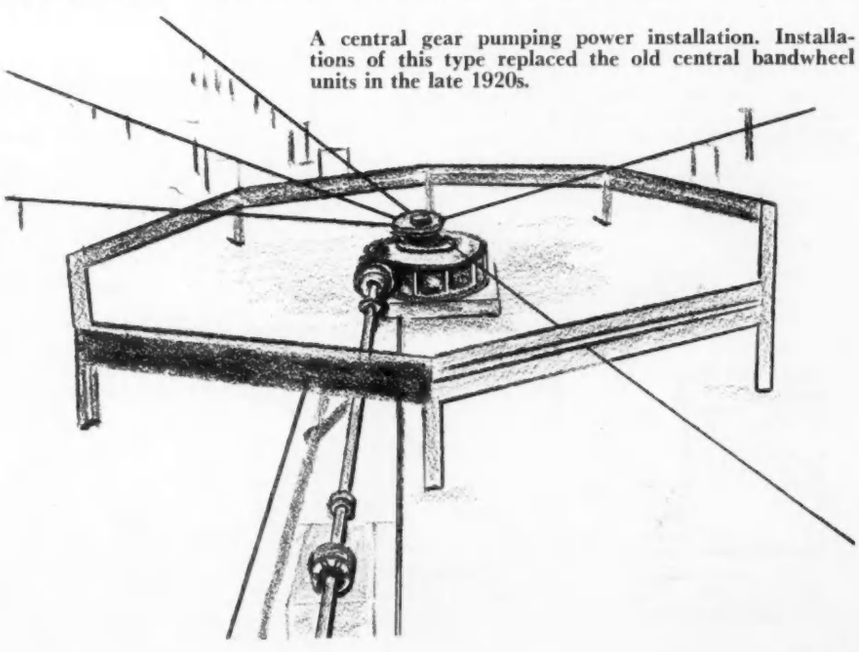
Fluid-packed pumps, for use in wells making a great deal of sand, appeared in 1927. Owing to its loose fit, sand caused much less abrasion in these pumps.

Insert pumps also were introduced during the 1920s. The feature of these pumps was the ability to pull the four essential parts (plunger, jacket and two valves) without pulling the tubing.

In the late 1920s, small diameter plunger insert pumps began to be used for pumping deep wells. They obtain desired production volume, and operate best at more strokes per minute than had been used previously. In turn, this called for better sucker rod steel.

A solution to the problem of high speed deep pumping was the introduction of long-stroke pumping units in 1924. The working stroke was increased to 84 inches at this time, permitting the reduction in number of strokes to 10 or 12 per minute instead of 16 to 24 by the

A central gear pumping power installation. Installations of this type replaced the old central bandwheel units in the late 1920s.



short-stroke units. This subjected rods to considerably less strain, without impairing the capacity if the pump.

Evolution in surface units. During the early days when the wooden derrick was in universal use, it was common practice to leave the derrick erected upon completing drilling activity. This derrick was used to facilitate pumping operations for many years.

The reciprocating motion was transmitted to the sucker rods through a walking beam. The operation was very similar to cable tool drilling. Power was by steam engines through belt drives to cranks that moved the walking beam.

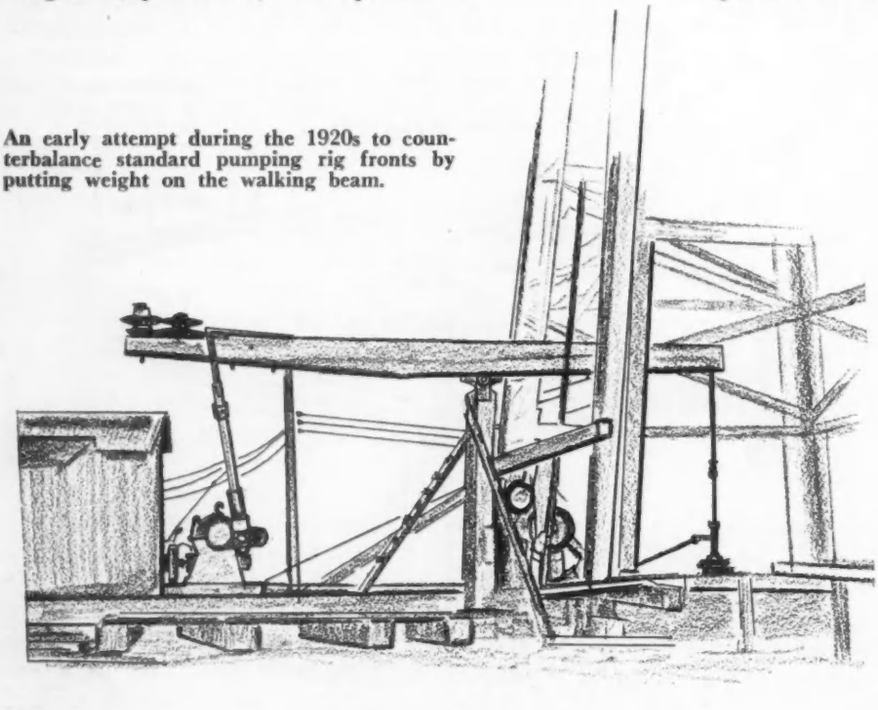
An early development was the operation of more than one pumping engine from a central boiler. The first gas engine designed for oil field service was marketed in 1894, and the first pumping by electric power took place in West Virginia during 1892. But steam continued to be the most popular pumping power for some time.

Central power pumping, whereby a large number of wells could be pumped simultaneously from a central power source, apparently came into use before 1900. Introduction of belt-driven bandwheel units soon followed, which through connecting rod lines permitted the use of small "jacks" to actuate the sucker rods.

Efficiency and size of central pumping powers were increased gradually, particularly with the introduction of heavy duty gear units that directly operated connecting rods.

However, rapid advancements in individual pumping units, coupled with the tendency toward greater depths, have made central power pumping obsolete.

The standard rig for pumping wells on the beam continued to be popular as an individual well unit. All-steel standard rig fronts were used widely during the 1920s. Many improvements in the standard steel rigs during the 1920s and early 1930s kept the standard rig front in the foreground, particularly in deep areas.



An early attempt during the 1920s to counterbalance standard pumping rig fronts by putting weight on the walking beam.

However, many forces were at work which were to eventually make obsolete the standard rig. As rotary drilling became more and more popular, it was apparent that the erection of standard pumping derricks was not economical. This situation touched off a series of developments during the 1930s.

First came the individual pumping unit, then the general development of portable well servicing equipment. The combination of individual pumping units combined with the portable rig served to not only replace standard rigs but also the production derrick.

Another change that contributed to the growing popularity of individual pumping units was the acceptance of high speed multi-cylinder gas engines and electric motors. The gas engine was the most popular until recent years, when more of the new installations have been equipped with electric motors. The Petroleum Electric Power Association has reported electrical sales for oil well power totaled slightly over 2 billion kilowatt hours during 1957, double that of 1953.

In the early days, most oil fields were isolated from any source of electric power. Scheduled shutdown of wells under proration increased the use of electric motors because of the ease of starting and stopping automatically.

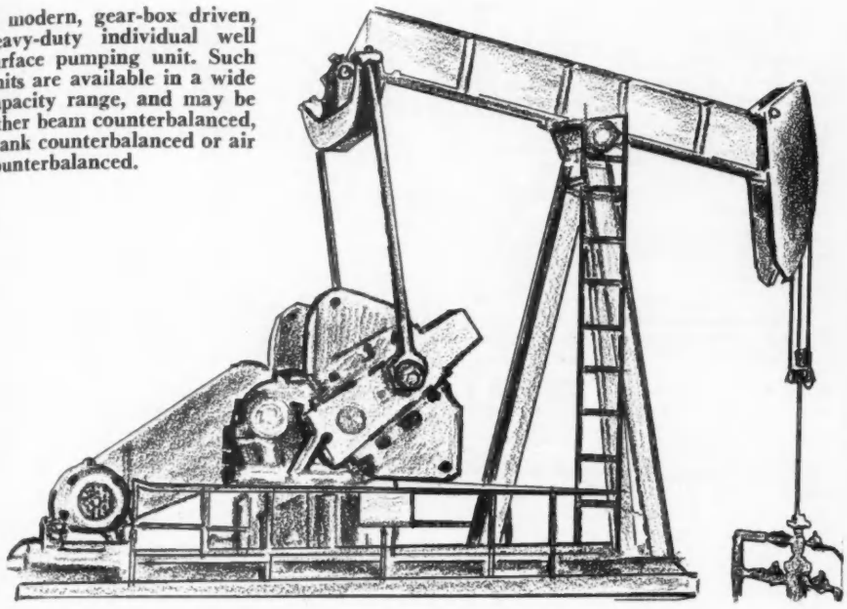
A growing desire to pump at slower speeds dictated the introduction of speed reducers. The first unit that remotely resembled the present-day pumping unit was built about 1920. It consisted of a train of cast-iron spur gears mounted on pillow blocks with no covering. A single pitman operated a steel walking beam, mounted on a vertical steel samson post.

The horsehead had not been dreamed up, and stuffing box wear was severe. Soon thereafter, a system of levers was used to impart a straight-line motion to the polished rod.

The next step was the introduction of units with right-angle drive worm gear reducers and counterbalances. In rapid succession thereafter, many other types of reducers were introduced. Finally, there came the single and double helical gear reducers. Improvements through the years have included twin crank units, back crank units, roller-type wrist pin bearings, needle type saddle, air balanced beams, etc.

In addition, hydraulic pumping units with suspended compressed air cylinders made their appearance in the early 1930s. A wide variety of these units are available today for every type of production from shallow stripper wells to deep high-volume wells.

Pumping studies become important. As wells were pumped from increasing depths, it became more and



A modern, gear-box driven, heavy-duty individual well surface pumping unit. Such units are available in a wide capacity range, and may be either beam counterbalanced, crank counterbalanced or air counterbalanced.

more apparent that measurement of stresses and distortions in rod movement was a problem of serious proportions. To this end, dynamometers were employed as early as 1923. Their use has increased and has been extended to cover many other rod pumping phases.

The first dynamometers merely recorded distortions imposed on the polished rod. It was increasingly evident that the operation of pumps one to two miles below the ground could not be deduced from surface recordings. Consequently, dynamometers were developed to record underground.

This development has led to greatly improved pumping operations, particularly in the application of proper counterbalances and sizes of equipment. In time, other instruments such as tachometers, engine indicators, fluid level measuring devices, strain measuring devices, and other instruments came to have a definite place in the study of rod lifting problems.

DEVELOPMENT OF RODLESS PUMPING METHODS

During the late 1920s, a submergible multistage centrifugal pump made its appearance in the U. S. The pump shaft is directly connected to an electric motor, and the entire assembly is lowered to the desired pumping depth. The unit proved capable of handling extremely large volumes, and has been used extensively where big quantities of water must be produced.

Since early 1932, more than 5,000 wells have been equipped with hydraulically operated rodless pumps. However, work on units of this type had begun as early as 1872, when H. W. Faucett and A. T. Comer were issued a patent. Subsequent proposals through the late 1800s and early 1900s are revealed by patent files.

However, these early models never received much attention. In 1922, R. R. Crum patented a hydraulic pump which was run in the Murphy Whittier, California, fields. Another hydraulic pump built by A. G. Gage was installed in the Santa Fe Springs, California, field in 1924.

I. B. Humphreys ran a large capacity hydraulic pump in the Mexia, Texas, field in 1927, and received two patents.

The first to manufacture and successfully operate a fully balanced double acting pump was C. J. Coberly. His first installation was in 1932 at Baldwin Hills, Calif. After undergoing additional improvements, the system was made available to the industry on a commercial basis. Oil pumped through a small diameter tube operates a bottom hole pump.

Many improvements have been made since 1932 in the art of hydraulic pumping. Important was the development of a method for circulating the bottom-hole pumping assembly in and out of the well for repairs without pulling the tubing strings.

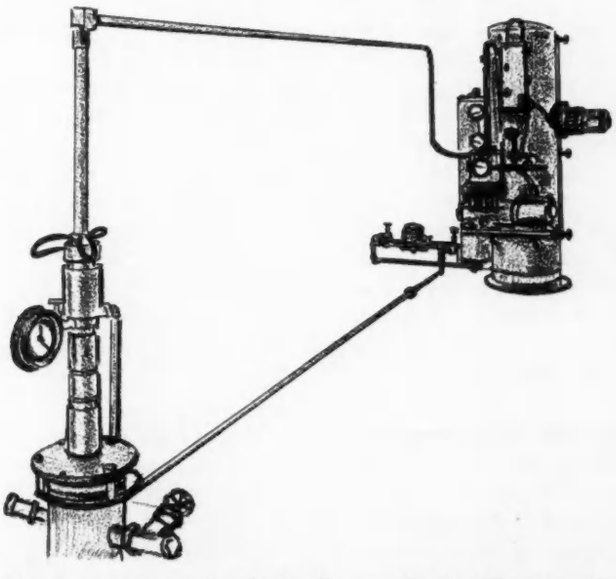
Modern hydraulic systems can utilize one central installation to provide the hydraulic power for the operation of any number of wells.

GAS LIFT UNDERGOES GREAT IMPROVEMENT

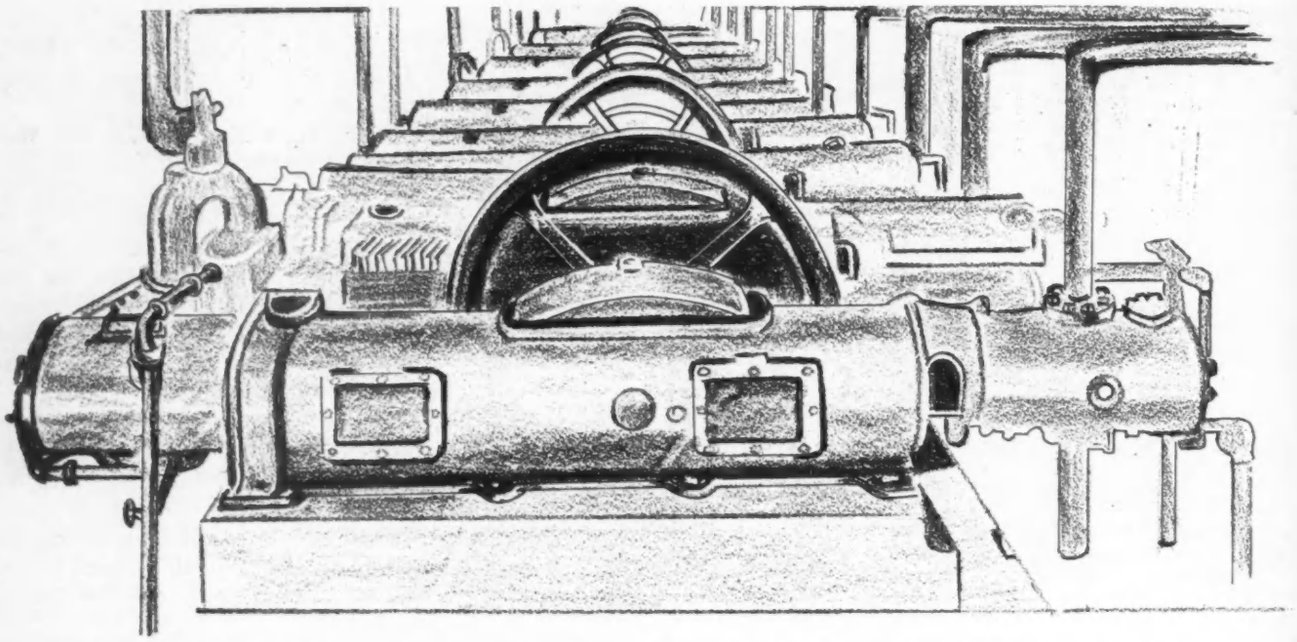
The oil industry adopted the use of air and then gas as artificial lifting methods early in its history, but they were not used extensively until the mid-1920s.

Air lift had been employed for more than half a century in lifting water when it was first applied to oil wells in Pennsylvania during 1864. Air lift was introduced in the Baku field of Russia and at Corsicana, Texas, in 1899. Air also was used at Spindletop, Texas, in 1901, where Spindletop Power Company built a central compressor station and sold air for oil lifting purposes.

Air lift was installed in the Cat Canyon, California,



The first modern rodless hydraulic pumping installation made in 1932.



A battery of 180-horsepower compressors installed at Seminole, Okla., central gas lift plant in the late 1920s.

field prior to 1911. The first use of gas instead of air is believed to have occurred at Cat Canyon during 1911.

Early gas-lift. Both air and gas was used as a lifting medium in various fields in the following years. They found their application where there was a need to artificially lift very large quantities of well fluid.

Gas lift began receiving a great deal of attention in 1924, and has been more widely used than air since that time. In 1924, gas was employed extensively in the Los Angeles Basin fields, and had been used for more than a year at Smackover, Arkansas, with good success. It was introduced in the Tonkawa, Braman and Seminole districts of Oklahoma in 1925. Use of the method spread rapidly, both in the U. S. and abroad.

Up to this time, all applications were of the direct lifting type. Large central compressor plants were utilized to inject gas into the wells. The most common practice was to inject into the annular space between the casing and tubing. With the end of the tubing below the fluid level, production was through the tubing.

Compressors of increased horsepower and efficiency were manufactured. Those in use at Seminole in the last half of the 1920s were capable of overcoming pressures of 1,000 pounds. Utilization of gas lift at Seminole at one time accounted for 250,000 barrels of production daily. Three-stage compression, permitting pressures up to 2,000 pounds, was used at Oklahoma City during the early 1930s.

Gas-lift improvements. With the wide use of gas lift during the late 1920s and early 1930s, engineers began extensive studies of efficiencies. This work soon resulted in marked improvements.

Kick-off collars spaced at intervals in the tubing string were introduced. They facilitated the starting of gas lift without providing high kick-off pressures.

There also was considerable progress around 1930 in the development of intermittent gas flow. This was achieved by the development of electrical, mechanical and pressure-operated surface-located timing devices. Smaller diameter tubing, including tapered strings, came into use. These developments made possible the utilization of gas lift for raising smaller quantities of oil, and prolonged its period of usefulness in the life of a well. Further progress in this direction used enlarged chambers into which the flow tubing string was inserted.

By the late 1930s, flow valves were being used extensively in gas lift installations in Texas and Oklahoma. Most valves operated automatically in response to the differential pressure between the casing and tubing. Other types of valves were operated by a weight bar run on a wire line, by rotating the tubing, and in response to fluid velocity changes. These proved valuable accessories, particularly under production curtailment. They also played an important part in making gas lift operations more flexible, in making intermittent gas-lift methods practicable, and in wells producing smaller volumes of oil.

The 1930s also saw the introduction of the plunger, or piston, gas lift and displacement pumping.

Modern gas lift operations are based upon the utilization of greatly improved flow valves for both intermittent and continuous lift. A sufficiently wide variety of flow valves is on the market to fulfill all needs. Many valves are selectively retrievable with wire line tools. Controllers for intermittent lift also have undergone great advancement. Retrievable flow valve mandrels with full open tubing bore is another development. Progress of this kind has increased the efficiency of gas lift greatly and has reduced the expense of pulling tubing to repair, adjust or replace equipment in the tubing string.

Such developments have made gas lift operations applicable to dual completions and the new permanently completed wells. They also have made the modern gas

lift installation easily regulated to meet changing well conditions.

OUTSTANDING STRIDES IN WELL STIMULATION

Several methods of stimulating well production are used by the industry today. Progress in these techniques are among the more prominent advances achieved by the industry. They have made huge quantities of additional oil available by increasing both initial and subsequent recoveries. Due to modern, highly efficient stimulation techniques, many wells that would have been abandoned as depleted in earlier years are producing today.

There appears to be no end to the progress in well stimulation methods. Many of the most significant advances are relatively new conceptions.

Progress in shooting. Use of explosives was the earliest well stimulation method to be used by the oil industry. Their first use in an oil well was in 1865 at Oil Creek, Penn. It was so successful in shattering a hard, tight oil sand that the method had widespread adoption at once.

Col. E. A. L. Roberts was the father of oil well shooting. It was he who exploded eight pounds of gunpowder in the well at Oil Creek in 1865. Roberts received a patent on the process in the following year.

The immediate success of oil well shooting probably was an influencing factor in the construction of the first U. S. nitroglycerin plant during 1867, which was 21 years after the first nitroglycerin was made in Italy. The use of explosives by the oil industry spread so rapidly, a nitroglycerin plant erected exclusively for the oil industry was built near Titusville early in 1869.

Early procedures consisted of pouring the explosive into metal containers, or shells, at the well. By the late 1920s, double-walled containers were in common use. Nitroglycerin was poured into the inner shell, and water was poured into the annular space between the two shells.

The first detonating device was merely a cylindrical weight dropped from the surface to strike the firing head. The next step was the use of wire line squibs, which contained a fuse and detonation cap. Hollow weights, or go-devils dropped down the wire to strike the firing pin.

Several modifications of the squib method were in use for some years. Next came electrically-operated detonators. The time bomb, which may be set to explode at any selected interval after the shot is placed in the hole, did not make its appearance until around 1920.

Thereafter, principal improvements in shooting techniques have been in the manner of placing and tamping the charge. Studies revealed that tamping was important as a means of confining explosive energy in oil wells. This increased the effect of the explosion on the producing formation. Tamping, usually with damp sand, came into universal use during the early 1930s.

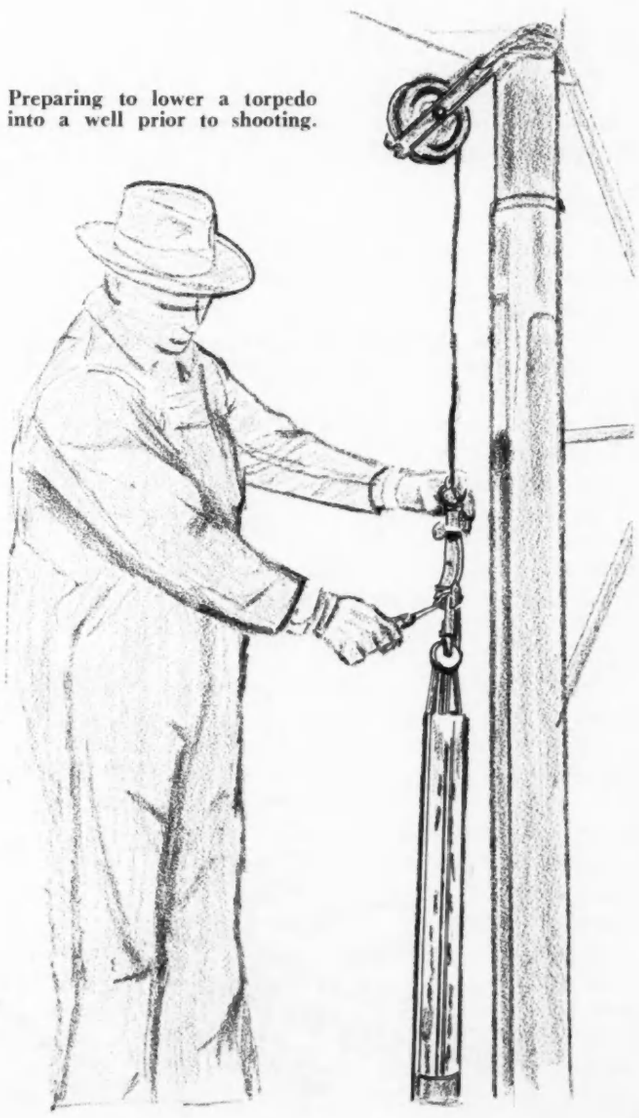
The largest amount of nitroglycerin used in shooting an oil well was 5,200 quarts exploded in a Turner Valley, Canada, well in 1946.

Uses of shaped charges. An entirely new concept in open hole shooting was made available to the industry with the advent of shaped charge perforating. It was found that flow channels could be opened around the bore of uncased holes.

The original shaped charge gun equipment for open holes was tested in 1946. Promising results led to further experimentation. A new design was introduced in 1948. The latter made no attempt to protect the charges from well fluids. The jet effect was achieved by cementing two hollow glass cones together. Later improvements utilized improved metallic liners and pressure tight explosive vessels.

Such operations offer better control of direction and penetration. Shaped charges of the open-hole type also have been used in waterflood producing and injection wells. The use of shaped charges for perforating casing has been discussed in the chapter on Completion Methods.

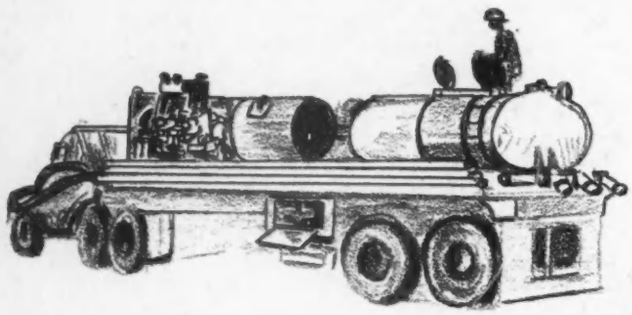
Vacuum used for a while. Use of vacuum in an effort to recover more production was applied to wells in the



Preparing to lower a torpedo into a well prior to shooting.

Oil Creek, Penn., field as far back as 1869. The practice came into wide use in partly depleted fields.

Because of the suction effect on the producing sand, protest arose over the effects of vacuum on adjoining properties. Today, the method is used rarely, and then as a protection against drainage of oil to wells on adjoining leases where vacuum is being applied.



Modern acidizing trucks include chemical tanks and necessary pump injection equipment.

Many acidizing improvements. Hydrochloric acid was used by Herman Frasch and John W. Van Dyke, of Solar Refining Company, to stimuate limestone producing wells in the Lima, Ohio, area as early at 1894. However, it did not come into wide acceptance until the introduction in 1932 of inhibiting agents to minimize the corrosive action on metal equipment. This technique was first used in Michigan brine wells, then adopted by the oil industry.

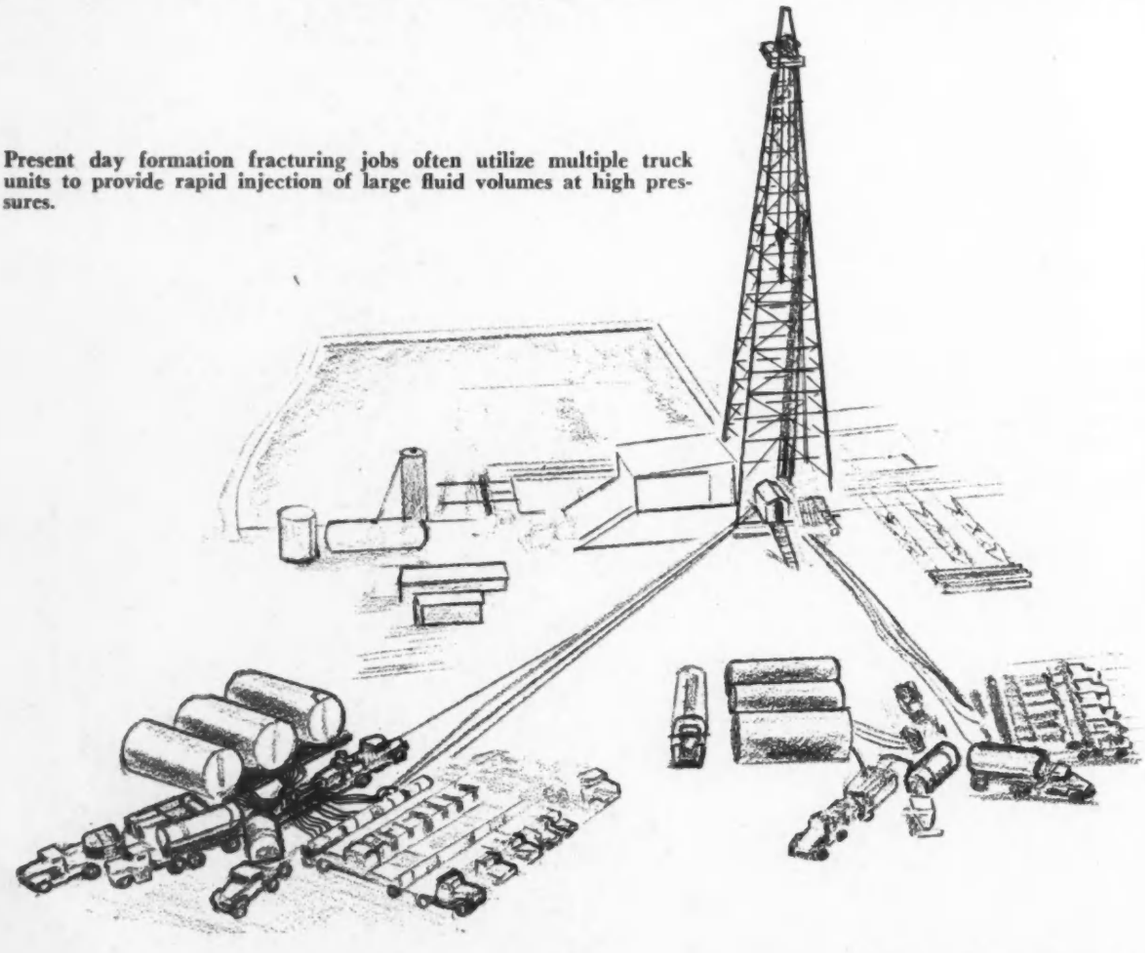
By 1936 acidizing methods had improved considerably. Different chemicals were in use, and it was learned which formations best responded to each. Several good inhibitors also were on the market by 1936, and especially designed trucks had been developed by service companies.

An estimated 14,000 wells were treated with acid between 1932 and 1939. Over the years, acidizing success has been improved constantly through introduction of better chemical agents, demulsifying compounds, etc. Servicing equipment also has been improved, permitting treatments in higher pressure wells. More than 200 million gallons of various chemical solutions and mixtures are estimated to have been used in 1957 in treating approximately 80,000 wells in the United States, Canada and Latin America.

A feature of modern acid treatment is the ability to control the acid and to adapt it to special well conditions. Many wells which operators were on the verge of abandoning have responded to acid treatment. Today, acid treatments are used during any stage of a well's life, from initial completion to the near-abandonment stage. Some new limestone fields are commercially productive today only because of acid treatments.

Formation fracturing highly beneficial. The well stimulation procedure which has done more to improve oil production is hydraulic formation fracturing. The

Present day formation fracturing jobs often utilize multiple truck units to provide rapid injection of large fluid volumes at high pressures.



technique is one of the greatest advances in the illustrious engineering history of the oil industry. It has been estimated that 10 percent of the oil reserves in North America could be attributed to fracture treatments by 1958.

The idea of hydraulically fracturing petroleum bearing formations to produce permeable flow channels, then keep them open with a propping agent, was conceived during World War II. Laboratory work found that gasoline thickened with napalm, an aluminum soap used in flame thrower fuels, was satisfactory as a fracturing liquid. By adding water to the gel and using a gel breaker chemical, the viscous gel was converted to a thin liquid which prevented the fracture from being plugged by the fracturing fluid during subsequent producing operations.

The first field job was conducted in 1947 in the Hugoton, Kansas, field. Stanolind Oil & Gas Company (now Pan American Petroleum Corporation) announced the development of the process in 1948. It became available to the industry in 1949.

The method was accepted widely immediately after its introduction. From March, 1948, until July, 1958, an estimated 227,000 fracturing treatments were conducted in the U. S. and Canada.

As fracturing was applied to more wells under widely varying conditions, outstanding process refinements have taken place.

Specialty acids were developed for treating carbonate rock formations. Viscous refined oils were found to be less expensive and less hazardous to use as fracturing fluids. Multiple fracturing was developed for use where it was not practical to isolate specific zones for individual treatments.

Better fracturing equipment has made it possible to conduct large volume, high injection rate treatments. Special equipment has been designed to blend the sand propping agent with the fracturing fluid. Specially designed packers suited for high differential pressures encountered in fracturing operations helped make fracturing operations successful.

Low fluid loss and low viscosity fracturing fluids were developed to overcome friction losses. They proved more efficient than viscous liquids or gels since they required less injection pressure. Soap insitu gels are other fracturing fluids now in use.

New hydraulic fracturing techniques have expanded the applicability of the basic process appreciably. Ball sealers are used for selective fracturing of perforated zones in cased holes. Single plane multiple casing perforators are used for confining fractures at a desired elevation in the producing pay. Controlled fracturing through perforations is achieved by matching the number and location of the perforations with the injection rate, insuring that fluid enters and fractures at all perforations.

Methods have been developed for inducing vertical fracturing by the special application of non-penetrating fluid and bridging materials. It now is possible to place horizontal fractures by use of bridging materials in gels or other viscous fluids in conjunction with wall scratchers or gel breakers. Methods have been developed whereby the aerial extent of fractures and efficiency of fracturing fluid can be calculated. There have been other improvements in propping agent size, strength and placement methods which produce high capacity fracture.

Many of the fracturing treatments now being employed are large volume, high injection rate treatments. Typical fracturing jobs will use 20,000 to 40,000 gallons of fracturing fluid containing 10 to 20 tons of propping agent, pumped at 20 to 50 barrels per minute.

Fracturing is used not only as a stimulant for old wells but also as initial completion procedure in many fields. Fracturing also has found a place in secondary recovery operations, where it is used in injection wells in addition to producing wells.

U. S. SECONDARY RECOVERY OPERATIONS

Secondary recovery operations play a very important part in the industry's current production volumes. This is particularly true in the United States, although secondary recovery also is practiced in a number of other countries.

Tremendous technological progress has led to greater secondary recoveries. Whereas primary producing methods probably will yield from 25 to 30 percent recovery efficiency in the average U.S. reservoir, application of gas injection probably would increase this to 35 percent, or slightly higher. Subsequent water-flooding frequently will increase the ultimate oil recovery efficiency in the average field to 45 percent or more.

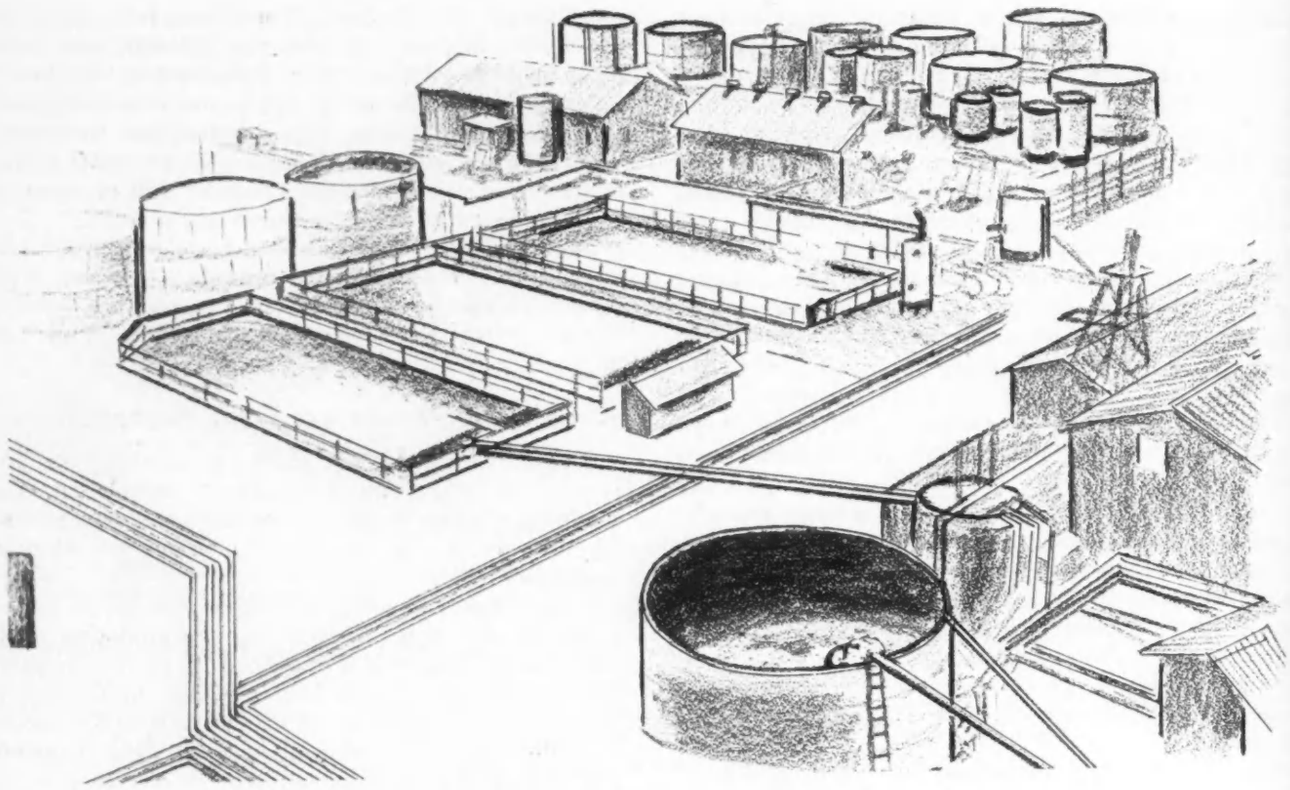
The Secondary Recovery Committee of the Interstate Oil Compact Commission in 1954 estimated that secondary recovery operations in the U. S. would result in the production of 11½ billion barrels of additional oil, or slightly over one-third of total proved U. S. reserves. At the same time, the committee estimated that full-scale application of secondary recovery in the United States might increase maximum recovery by 29 billion barrels.

Fluid injection operations accounted for the production of approximately 265 million barrels of oil during 1953 in the United States, according to the Interstate Oil Compact Commission. This is exclusive of the East Texas water injection program. At the same time, the commission pointed out that the total number of fields in which secondary recovery was practiced in the United States had risen from 414 in 1946 to more than 1,000 in 1953.

Growth in gas repressuring. Production from gas injection projects in the United States has increased from less than 10 million barrels annually in 1925 to about 37 million barrels in 1935, and to approximately 170 million barrels in 1953.

In 1888, James D. Dinsmoor observed the results of the accidental repressuring of three wells in Venango County, Pennsylvania. Two or three years later, Dinsmoor turned gas from one sand into another producing formation. Although depletion of the gas supply limited the operation to a period of about six months, production more than doubled in nearby wells. This operation also was in Venango County.

In 1895, Dinsmoor attempted the first known combination of repressuring and vacuum in Clarion County,



Large scale water injection plant includes numerous skimming and settling tanks.

Penn. Dinsmoor and associates acquired extensive properties in West Virginia and then in Pennsylvania during the following years, on which he combined repressuring with vacuum. In 1909, Dinsmoor is believed to have been the first to use a compressor for gas injection purposes. It is interesting to note that Dinsmoor utilized back pressure at the producing wells to control high gas-oil ratios. He also had the foresight to equip wells with pressure gages and meters.

Dinsmoor's success in increasing the production of partly depleted properties led to other operators adopting the practice.

The earliest known attempt to increase oil recoveries in Ohio by repressuring was conducted by I. L. Dunn, near Marietta, in 1903. In 1911, Dunn was very successful in applying air repressuring in the Chesterhill field of Ohio. After four years of air repressuring, annual production had almost doubled to over 16,000 barrels. In 1915, James O. Lewis estimated almost 4,000 wells in southeastern Ohio were affected by repressuring, with over 90 separate projects in operation.

Chesterhill was the first extensive repressuring project. It was not until 1916 that an entire field in Pennsylvania was repressured. This was the Hamilton Corners field, near Oil City. It was the first unitization program in the industry's history.

Although the benefits of gas injection now were well established, it was not widely applied until the mid-1920s. The first repressuring in Illinois was in 1921. The first in Oklahoma was in the Nowata area in 1917. A few small repressuring projects were operated in Texas in 1924 and 1925, but the first large scale program was at Petrolia in 1926. During the following years, a number of gas repressuring projects were started, including many notable programs.

Injection of light hydrocarbons. There is evidence that oil recovery efficiencies in reservoirs can be increased through the injection of light hydrocarbons. Such fluids have been injected in a number of fields in recent years.

The general practice is to mix ethane or propane, or both, with natural gas. Among other benefits, this method improves the gravity of the oil, reduces paraffin, reduces gas-oil ratios.

Growth of water-floods. Water-flooding is believed to have had its inception in Pennsylvania prior to 1900. It is said that when withdrawing casing from abandoned wells near Aiken, in McKean County, water from upper levels accidentally flowed into the producing sand. This led to agreeable but surprising increases in production of nearby wells.

Operators considered such operations to be illegal due to a Pennsylvania law which required that abandoned wells be so plugged to prevent water intrusion from one sand to another. Consequently, application of the method was conducted under a clandestine cloak and no early records are available.

The first intentional water-flooding apparently started in

the Bradford, Penn., field. Increased production was noted around 1906. The first beneficial effects of water-flooding were noted in nearby New York oil fields in 1912.

However, it was not until the practice was legalized in New York in 1919 and in Pennsylvania in 1921 that water-flooding came into extensive use in the northern Appalachian fields. Production of the Bradford field rose from less than 1½ million barrels yearly in 1907 to over 16½ million barrels in 1937.

Intensive water-flooding was practiced only in the north Appalachian fields until the 1930s. The first water-flood project elsewhere was commenced at Nowata, Okla., in 1931, and was followed in 1934 with the first systematic operation patterned after methods employed at Bradford. This project established the effectiveness of water-flooding in the Mid-Continent region. Many additional floods have been commenced since that time.

Active application of water-flooding did not begin in the shallow eastern Kansas fields until after the success of systematic floods in Oklahoma. However, haphazard flooding is believed to have been in operation around Chautauqua, Kan., as early as 1916.

Partly accidental floods have operated in Illinois since 1924, but intensive activity did not exist until the 1930s.

Water-flooding started in the Chatham field of Ohio in 1939. The first flood in Kentucky was in 1942.

Two water-floods were started in Texas in 1930, in Brown County and Wichita County. It was not until 1944 that the first water-flood commenced in California.

Water-flooding operations have reached a large systematic scale in all these states since their initial applications.

The largest water injection plant has a capacity of 200,000 barrels of water per day. It is located in the Kelley-Snyder, Texas, field.

Great technological progress. Application of engineering methods has had as significant an impact on secondary recovery operations as on primary recoveries. The first modern cable tool core barrel was used at Bradford in 1928. Evaluation of fluid and characteristics of the reservoir through the medium of core analyses spread rapidly, making it possible to accurately predict probable flood yields. Paul D. Torrey is credited with establishing the first secondary recovery commercial core laboratory in 1928.

From this infant beginning, secondary recovery reservoir engineering has been developed into a highly perfected scientific art. Through such studies it has been possible to increase oil recoveries and to make some previously unsuccessful projects profitable.

Combination of reservoir engineering with new tools and chemical agents has made it possible to isolate gas and water sand from injection fluids by packing or casing off the gas sand and plugging back the water sand. Differential movements today are controlled through sand sections of variable permeabilities by packers. Selective shooting has made possible an increase in permeability of low permeable sections. Instruments are available for determining injectivity rates. A large variety of other specialized tools have been developed to aid in reservoir evaluation.

Improvement in quality of injection water has contributed greatly to increased ultimate recoveries. Both open and closed water systems are in use.

Research programs big aid. Recognition of the part scientific studies could play in improving secondary recovery operations led to the State of Pennsylvania establishing a research program at Pennsylvania State College in 1929. This program was augmented in 1933 by the Bradford District Pennsylvania Oil Producers Association in 1933. Subsequently, the Pennsylvania Grade Crude Oil Association contributed to this research work. Expenditures for research in the Pennsylvania area had reached $200,000 per year by 1949.

The U.S. Bureau of Mines has been active in advancing secondary recovery methods. Much work has been conducted at both the Bartlesville and Franklin stations of the bureau. API established a Secondary Recovery Committee in 1939. The Independent Petroleum Association of America and the Interstate Oil Compact Committee also have been active in helping to advance secondary recovery operations.

Mining for petroleum. There has been very little engineering work on mining of petroleum in the United States. However, it has been used in other countries, particularly in France and Germany. The best known petroleum mining operations are at Pechelbronn, France, and at Wietze, near Hannover, Germany.

Galleries were driven into the outcrop of bituminous sands at Pechelbronn in 1935. By 1765, Pechelbronn galleries were said to be 1,500 feet long and to have been sunk to depths of 160 feet. Mining at Pechelbronn ceased between 1880 and was not resumed until 1916. At this time Pechelbronn was in the hands of the Germans. Mining operations produced 134,000 barrels during the year 1918. The French have operated Pechelbronn continuously since 1919.

Mining operations in Germany began in 1919. Mining for petroleum was undertaken in Japan in 1940. During World War II, the Australian government attempted to mine oil bearing sands at Lakes Entrance.

The first oil shaft to be sunk in the United States was in 1859 near Tarentum, Penn. A mine in 1865 at Tidioute, Penn., reached a depth of 160 feet, when gas caused an explosion. During the 1860s, other shafts were dug in Pennsylvania, Ohio and California. A series of 31 drainage shafts reportedly was started in 1866 in Ventura County, California. One tunnel reached a length of 1,900 feet. Production in this operation increased to about 140,000 barrels yearly in 1895.

Since 1900, mines have been sunk in Colorado, Kansas, Missouri, Pennsylvania, and Texas. Although a few produced a little oil, none was profitable. The latest U. S. attempt was in 1942 at Rocky Grove, Penn. It appears

unlikely that mining will receive much attention as long as the world has an abundant supply of petroleum.

Oil recovery from outcrops. Many attempts have been made to recover oil (bitumen) from outcropping sandstones. As early as 1891, such operations were under way in California. One plant, which operated at Carpenteria, Calif., between 1891 and 1899, had a capacity of about 15 tons of refined bitumen. Other California plants operated in the late 1800s and early 1900s.

A plant was built to recover bitumen near Uvalde, Texas, in 1893. From 1911 to 1913, butuminous sandstone was mined at Woodfork, Okla. Many other attempts were made in the United States to mine bituminous rocks and recover oil before the 1920s. One of the most recent attempts was at Vernal, Utah.

The world's largest deposit of outcropping bituminous sandstones is in the Athabaska area of Alberta, Canada. It has been estimated that 5 billion barrels of oil might be recovered from Athabaska mining, without considering possibilities underlying the overburden. Large sums of money have been spent in trying to profitably recover the Athabaska oils, but none has succeeded to date.

High-pressure enriched injection. Laboratory studies led to publication of report in 1950 which proposed the injection of enriched gas into oil reservoirs at much higher pressures than those with conventional gas pressure maintenance. These studies indicated considerably higher recoveries would be possible. Subsequent field applications have proved this concept can be applied in many reservoirs, and, in some cases, may approach 100 percent recovery of the oil in place from contacted areas.

There are two types of high pressure gas injection processes. In one, the enriched displacing gas is immiscible with the reservoir oil. In the other instance, the displacing gas becomes so enriched it is miscible with the reservoir oil.

In immiscible drives a more favorable displacement is possible because displacing gas is more viscous than the oil being displaced and because the undersaturated oil in contact with the gas swells, leaving less of the original reservoir content as residual oil.

The displacement mechanism in miscible drives is basically that of light oil displacing a heavy oil. This type of displacement is highly efficient, displacing essentially all the oil in the contacted area except for bypassed islands.

Recovery by thermal methods. The industry long has given much thought to the application of heat as a means of obtaining additional recovery from partially depleted reservoirs. Laboratory tests have indicated heat would reduce viscosity, alter interfacial tensions, and change the physical state of oil in place. Several attempts have been made over the years to apply steam. However, difficulties in making such methods effective over whole reservoirs made them impractical.

Two new interesting techniques of applying heat to oil reservoirs have been introduced in recent years.

Magnolia Petroleum Company applied the in-situ method in Oklahoma during 1953. In this procedure, thermal energy is generated by burning a portion of the reservoir's oil while it is in place. By supplying oxygen-bearing gas through an injection well, a traveling fire front sweeps crude oil and water ahead of it as a result of the combined effect of the heat generated by combustion and the flow of combustion gases.

Since its introduction in Oklahoma, several additional in-situ projects have been installed. Results generally have indicated favorable possibilities.

A number of completely submergible electric formation heaters have been used in the Cut Bank, Montana, field since 1950. They have yielded attractive production gains, perhaps because the application of heat removes paraffinic residue from the sand face and reduces reservoir fluid viscosity in the immediate vicinity of the well bore.

MUCH PROGRESS IN WELL WORKOVER TECHNIQUES

Tremendous strides in well remedial work have prolonged the life of many producing wells, resulting in increased production. Such workover operations involve numerous techniques developed for a wide variety of different conditions.

Modern completion and production techniques, as well as improved equipment, have reduced the frequency of workover jobs. They have resulted in reduced operating costs and increased production. However, workover operations still constitute a major production problem.

Well bore cleaning. Utilization of perforated casing, screens and plastic sand consolidation chemicals, discussed in the chapter on well completion techniques, has led to greatly reduced troubles in loose producing formations. However, such wells suffer from the plugging effects of unconsolidated sands that move toward the well bore with production.

A number of well washes have been developed during the past 20 years or so which have improved cleanout efficiencies. Various types of oil washes, water base chemicals and heat generating chemicals have been introduced to clean perforations and to remove plugging material from near the well bore.

In addition, improved washing tools have been designed. Many different applications have been found for circulating type and pressure type washers, which have proved more effective than the early methods of swabbing detrital material from behind perforated casing and liners.

Another method of removing clogging material is the use of explosive cords. The discharge of explosive cords releases sufficient lateral force to dislodge material accumulated in casing and screen perforations.

Plugback improvements. Advances in plugback materials and techniques have made possible the selection of the most favorable section of the formations. This ability has made possible the reduction of high gas-oil ratios, the shutting off of bottom-hole water, repairing of casing and plugging back to upper producing zones.

Among numerous techniques which have helped im-

prove production operations is squeeze cementing, which was introduced in the early 1930s. Used in conjunction with modern casing perforating techniques, squeeze cementing constitutes a great advancement in well remedial work.

By setting a cement retainer or retrievable cementing tool at the desired depth, cement may be forced by pressure into the formation. After obtaining a desired squeeze pressure, excess cement is reversed out. Cement remaining in the bore hole or casing then is drilled out to a desired point. Usually, the squeeze job is dry-tested and re-perforated if necessary. Introduction of retrievable cement retainers in 1939 was a notable advancement in squeeze cementing.

In addition to the use of cements to exclude water, chemical plugging materials have been developed. Plastic materials for this purpose came into use in 1942, notably in the East Texas field. Penetration of the plastic into the formation is controlled partly by pressure applied at the surface. The plastic hardens, like cement.

Considerable improvement and changes in physical properties of plastic plugging materials have taken place in subsequent years. These advances have provided better control and made plastic plugging work applicable under a wider variety of conditions.

The source and point of entry of water into a well must be determined before a program for its exclusion can be selected intelligently. Several instruments have been introduced during the past decade or two which will determine the point at which water is entering a well. These instruments have improved the efficiency of plugback operations greatly.

Paraffin and scale control. One stubborn and expensive production problem since the beginning of the oil industry has been the accumulation of paraffin and various scale deposits in both surface and subsurface equipment.

Over the years, several different methods have evolved for the removal of such accumulations. A common method involves the introduction of steam into tubing, flow lines and other equipment. Portable steam boilers capable of generating large volumes of steam are available today.

Other methods involve the utilization of solvents, often preheated, use of chemicals, numerous mechanical scraper devices, crystalline metal conditioners, and soluble plugs.

Well servicing equipment. Great progress in well servicing equipment has wrought an equally great change in production maintenance practices. Highly efficient portable well servicing units have resulted in the removal of derricks from producing wells in many areas. Normal practice during the early years of the industry was to leave the drilling derrick in place.

In the 1920s, special production derricks came into use. These were shorter than drilling derricks. During the 1930s, the production derrick began to be replaced by production masts, which could be set up permanently, semi-permanently, or could be combined with portable servicing units. Early combination servicing units did not have high enough masts, and it was necessary to lay sucker rods and flow strings on the ground when servicing the well. Since the late 1930s, truck-mounted telescoping derricks have overcome this problem, and the practice of removing all derricks from producing wells has become common.

The first portable well pulling units were introduced in 1918 by Fred E. Cooper. They consisted of a portable winch mounted on a steel-wheeled tractor. Up to this time, horses and mules were being used to pull rods and tubing from many of the wells. Most wells, however, were equipped with bullwheels for such operations.

The pulling speed of the first units could be regulated only by controlling the tractor engine speed. The next improvement was to add varying line speeds to the drum. A big forward stride took place in the early 1930s with the introduction of high speed tractors that utilized large low pressure tires. This permitted the engineering of winch equipment for higher speeds, the larger units with as many as eight line speeds on the drum.

Subsequent years have seen the introduction of skid-mounted winches, truck-mounted units and trailer-mounted units. Such modern units are available today with spudding equipment for drilling-in or cleaning-out wells with cable tools, rotary drive equipment for well reconditioning and deepening, portable mast equipment, advanced clutches and transmissions.

TREATING OIL-WATER EMULSIONS

Efficient plugging off methods have proved tremendously helpful in reducing the quantity of water produced by oil wells. Furthermore, engineers have learned that emulsions can be made more difficult to treat if turbulence is permitted to thoroughly disperse water in the oil. Nevertheless, oil wells still produced entrained formation water, and the treatment of these emulsions is an expensive and sometimes difficult problem.

The problem of separating entrained formation water

A 1918 tractor-mounted well servicing unit (left) and a modern deep well portable servicing unit (right).

from oil began to receive serious attention by 1900. Improved methods were introduced in the early 1900s. These methods have undergone constant study, with the result that great advances have been made in the intervening years.

Methods of treating crude emulsions include gravity settling, heat treating, electrical, chemical, centrifugal, and filtration.

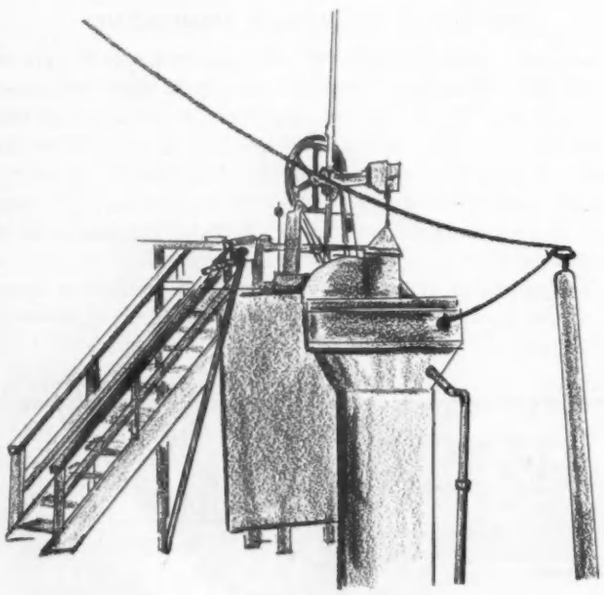
Gravity settling. This is one of the oldest emulsion treating methods. Operations necessarily must be conducted in large containers, which may be a tank, sump or earthen reservoir. Fluids are permitted to come to rest for a suitable period of time to allow settling of the water.

This method frequently is used in conjunction with heating and chemical treatments.

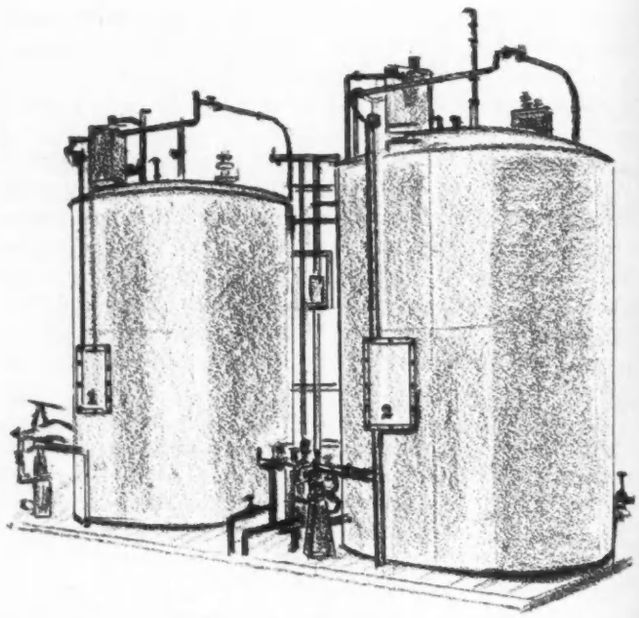
Heat treatment methods. Application of heat to emulsions has been found an effective dehydration means in many instances. Heat is applied in numerous ways: passing the emulsion through hot water; by injection of steam or hot air; by direct heating in a pipe still, boiler, or other type of furnace, or by indirect heating in heat exchangers.

Heat treating is an old method, but many worthwhile improvements have been made in design. Many modern treating units perform the separation of oil and gas, removal of free water, application of heat for breaking emulsions, and provide settling facilities. Both indirect and direct heaters are in use. These have been developed through constant advancements in design since the 1920s.

Electrical dehydration. Dr. Frederick G. Cottrell, of the University of California, in 1906 developed a system for condensing solid particles by applying rectified alternating electric current. Three years later, Dr. Cottrell set up a commercial installation which successfully reduced an emulsion of 14 percent of water to less than 2 percent.



Open-top electric dehydrator installed in California field during 1911.



Present day enclosed electric dehydration installation provides continuous automatic removal of water and basic sediments.

Within a year, another plant with various improvements was built in California.

The first electric dehydration units were of the open type. An enclosed unit was put into commercial use by 1919, and the old open electric type dehydrators were discontinued. This overcame serious evaporation losses and reduced fire hazards.

A vast amount of research has developed the electrical treating process to a high degree of efficiency today. Several types of electric dehydrators are available today, each adapted to different types of emulsions or conditions of treatments.

Chemical demulsifiers. William S. Barnickel, a St. Louis chemist, began investigating oil-water emulsions in 1907. By 1911, Barnickel put a chemical process on the market.

Constant research has developed many different commercial chemicals for treating oil field emulsions. Some varieties are oil soluble, and others are water soluble.

Chemical treatment frequently is used today in conjunction with the application of heat. The type of chemical demulsifier used and whether heat should be applied depend upon the nature of the emulsion.

Centrifugal emulsion separation. Dr. Gustaf De Laval invented the first practical machine in 1878 for the separation of two liquids of different specific gravities. Dr. De Laval soon worked out a process for purifying crude oils, refinery oils, skimming plant oils, and fuel oils.

The centrifuge over the years has been improved in efficiency. In addition to petroleum treating problems, it is used in many other industries. Modern centrifuges are capable of developing rotational speeds in excess of 15,000 revolutions per minute, permitting them to develop a force far greater than that of gravity.

Filtration treating methods. Many processes have been developed for the separation of emulsified oil and water by filtration under pressure. Numerous patents cover the use of various porous mediums.

Filtration media has ranged from wet canvas bags, oil wet filter cloth, excelsior, sand, diatomaceous earth, glass wool, and other filtering mediums.

"Hay tanks" filled with excelsior, or other material, is one of the most common filtration treating methods. The hay tank usually is used in connection with a gun-barrel tank, and heat often is utilized to improve separation efficiencies.

Gas dehydration methods. Use of traps, or drips, in gas lines to collect liquid water dates back prior to 1900. Devices to automatically bleed water from traps were used by 1900.

Dehydration of natural gas became increasingly important with discovery of high pressure formations, the most notable examples being distillate producing fields. As pressures rose, freezing troubles increased. Until the early 1940s, freezing was prevented by heating the gas above the hydrate-formation point when passing through regulators and chokes. In some instances, alcohol was injected into gas lines to prevent freezing.

Continued trouble led to the introduction of wet-type gas dehydrators using diethylene glycol as the absorbent. Until the late 1940s, practically all wet-type dehydrators were installed at gasoline plants or in central locations where relatively large volumes of gas was processed. Introduction of smaller capacity units made it possible to install wet-type dehydrators at wellheads.

The late 1940s also saw the development of dry-bed dehydrators. These units pass gas through a bed of mineral agents to absorb the water. A number of drying agents has been used.

Early dry desiccant processes were not suitable for wellhead installations, being too large and expensive. However, by mid-1950 wellhead dry desiccant dehydrators had been developed, and were in use. Early installations operated under pressures from 50 to 3,500 pounds per square inch, and with temperatures ranging from 45 to 120 degrees fahrenheit.

Subsequent improvements have ironed out many of the troublesome problems, and increased the efficiencies of dry bed wellhead adsorption units. Fully automatic, self-contained and skid-mounted units have been developed in recent years. Some of more modern units are a combination dehydration and hydrocarbon recovery device. They operate with no external source of energy other than the gas stream which is being processed.

SALT WATER DISPOSAL METHODS INTRODUCED

Disposal of water produced with oil and gas has been a troublesome problem since the birth of the industry. In the industry's earliest days, salt water was permitted to run free. This ruined many water streams, killing fish and preventing use of the water for drinking and irrigation purposes. Consequently, states enacted laws which prohibited such practices.

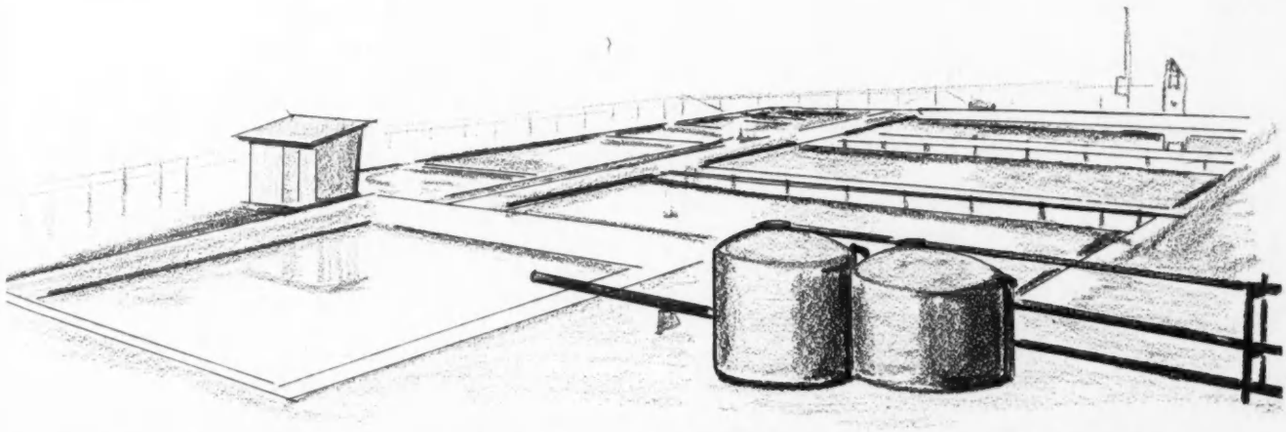
Thus, companies began using large surface evaporation pits. Until the mid-1930s it was a common sight to see numerous evaporation pits, or ponds, in almost every large oil field. Heat sometimes was applied to hasten evaporation.

The modern technique where large volumes must be handled is to dispose of the water by injecting it into subsurface formations. There is little information available on early attempts at subsurface disposal of oil field brines. Available records indicate old, dry holes were utilized at times for disposal purposes. A U.S. Bureau of Mines report published in 1929 mentioned subsurface disposal of brines only lightly. But in the next few years, this operation was to receive much consideration and to be adopted on a wide scale.

The literature describes brine injection systems in the Ritz-Canton, Kansas, field in 1935, and at several other fields by 1940. Thereafter, injection of salt water into subsurface formations became a normal operating procedure.

East Texas disposal system. Largest and best known salt water injection system is located in the East Texas field.

Salt water became a major East Texas problem in 1936. An experimental salt water injection well in that



Typical East Texas salt water disposal treating plant. Two filters in right foreground, three-compartment settling basin in background and backwash pit in left foreground.

year proved the feasibility of utilizing the oil producing formation as a disposal media.

Some salt water disposal wells were put in operation on the west side of the East Texas field in 1938. Water production continued to increase, and more salt water disposal wells were completed.

Nevertheless, the rate of water production grew faster than disposal wells were drilled. Meanwhile, additional engineering studies had revealed the importance of maintaining the field's reservoir pressure, and the existence of a west-to-east water drive in the field.

Consequently, operators formed a field wide disposal company in 1942. Injection rates rose from 50,000 barrels a day in early 1943 to more than 100,000 barrels by June, 1943, and to as high as 400,000 barrels per day in October, 1947.

During its first 10 years of operation, the East Texas Salt Water Disposal Company injected 1.1 billion barrels of salt water into wells drilled on the west side of the producing limits. As mentioned previously in discussing reservoir pressure maintenance, this has had a very beneficial influence on oil recoveries in the East Texas field. Pressure has been maintained above the point where gas comes out of solution, and may have added as much as 600 million barrels to the field's recoverable oil.

Disposal problems. Great progress has been made in the development of improved salt water handling operations since this became a widely used method in the early 1940s.

Corrosion always is a serious problem. Cement-asbestos, wood, coal-tar asphalt-impregnated fiber pipe, cast-iron vitrified-clay pipe, cement-lined pipe and plastic coated pipe, and plastic pipe are used in most disposal systems. Closed systems have been designed to alleviate corrosive action.

It also has been found practical to use cement or plastic lined tubing in injection wells. Many systems use cast-iron valves, fitting and piping because of corrosion.

THE DAWN OF OIL FIELD AUTOMATION

As the industry's first century draws to a close, the age of automation appears to be dawning for oil field operations. Much progress has been made in the last few years, and research under way promises rapid development of these techniques.

Gaging, sampling and testing to determine the quantity and quality of oil production now is being performed automatically. In addition, well flow, tank switching, and even custody transfer is being done automatically.

Early progress. One of the first steps toward automatic lease operation was the introduction of liquid meters in 1929. Early meters soon were obtainable with devices to compensate for temperature changes.

Another early development was the introduction by 1932 of time switches which automatically regulated the operating periods of electrically pumped wells. Pneumatic systems for use on engine driven pumping units were not long in being developed. These practices came into use in the East Texas field. By 1949, various types of automatic gas-control valves were installed on both flowing and gas-lift wells in the East Texas field.

Extensive development of automatic control systems and equipment was impossible during World War II. However, reliability of automatic equipment was demonstrated by the operation of previously installed systems. After the war, the application of automatic control equipment to both wells and tank batteries progressed at phenomenal rates in the East Texas field, and also spread to other regions. Recent years have seen great strides made toward complete automatic operation of wells and tanks.

Individual well testing. Means of automatically diverting the flow of individual wells into and out of separate metering facilities now are in use. New control panels sequentially select wells for testing, operate valves that divert flow through metering facilities for a predetermined length of time, then divert flow back into the regular flow line.

There are a number of such control panels available. Also several types of remote-controlled three-way valves have been introduced for well testing installations. Included among the valves are air-cylinder operated plug valves, diaphragm-operated valves and electric-motor operated valves.

Oil and gas measurement. There are a number of metering devices being utilized for automatic measurement of oil production today. The most common are the positive-displacement meter, volumetric dump meter and metering tank.

The orifice meter has been the industry's standard means of measuring gas for many years. Recently, totalizing orifice meters and positive-displacement meters have been developed to the point where they provide satisfactory automatic gas measurement.

Measuring water content. Several methods are being used currently to measure individual amounts of clean oil and water being produced. Some systems still are depending upon procurement of samples from manual traps. However, automatic samplers provide a means of obtaining representative samples. Several new types of recorders have been introduced recently, and promise to make this operation fully automatic.

Data processing. The collection of all measurement data is being handled automatically today. Data may be recorded on electro-mechanical counters or printed on tapes at the field station, or may be telemetered to central field offices.

If much more information than the quantities of oil measured during each test period are desired, use of computers is advantageous. Computers can be utilized to record water percent, rates of production and other information.

Automatic custody transfer. During recent years, producing companies have installed automatic devices at lease tanks to eliminate some of these time-consuming operations. Automatic operation of a tank battery is

accomplished by the use of electrically operated valves, float switches and a control of switch panel. This permits the switching of production from a full tank to an empty tank.

Only during the last few years have full scale installations being constructed for complete automatic custody transfer. This is an entirely new concept in oil field operations, which includes the measuring, sampling and running of crude oil from producers' tanks to connected pipe lines.

So much interest has been shown in this new concept, the American Petroleum Institute has organized a special committee to study and evaluate installations. A preliminary bulletin by the committee discusses these three methods of volume measurement: parallel measuring tanks; tandem storage with single measuring tanks; and positive-displacement metering.

At this time, various types of automatic equipment are being applied successfully to oil well performance-testing-gaging-transfer operations. Automation for such activity is sure to make rapid strides during the next few years.

PRODUCTION RISES AT EVER FASTER PACE

At the close of the industry's first century, world crude oil production had risen to more than 6½ billion barrels annually. The rate of growth has risen at constantly faster rates, particularly during the last decade or two. More than half of this growth has occurred during the last 12 years. World production today is over two times greater than in 1947, better than 3 times larger than in 1937, and five times greater than in 1927.

Annual crude oil production totaled only 300 million barrels in 1909, which was the industry's 50th year. By 1917, production had climbed to 500 million barrels. Five years later, when the industry was in its 63rd year, production reached 1 billion barrels.

Just 14 years later, in 1937, world production attained 2 billion barrels for the first time. But it was only another 10 years before production had risen to 3 billion barrels annually. Between 1947 and 1951, annual production rose to 4 billion barrels. By 1954, world production had increased to 5 billion barrels, then to 6 billion barrels by 1956.

World Crude Oil Production Growth by Principal Areas During the Past Four Decades
(Figures in Millions of Barrels Annually)

Area	1957	1947	1937	1927	1917
United States	2,618	1,857	1,279	901	335.0
Venezuela	1,014	435	186	63	0.1
U. S. S. R.	571	187	193	77	63.0
Middle East	1,292	306	117	40	7.0
Other Countries	1,035	237	264	182	97.9
World Total	6,530	3,022	2,039	1,263	503.0

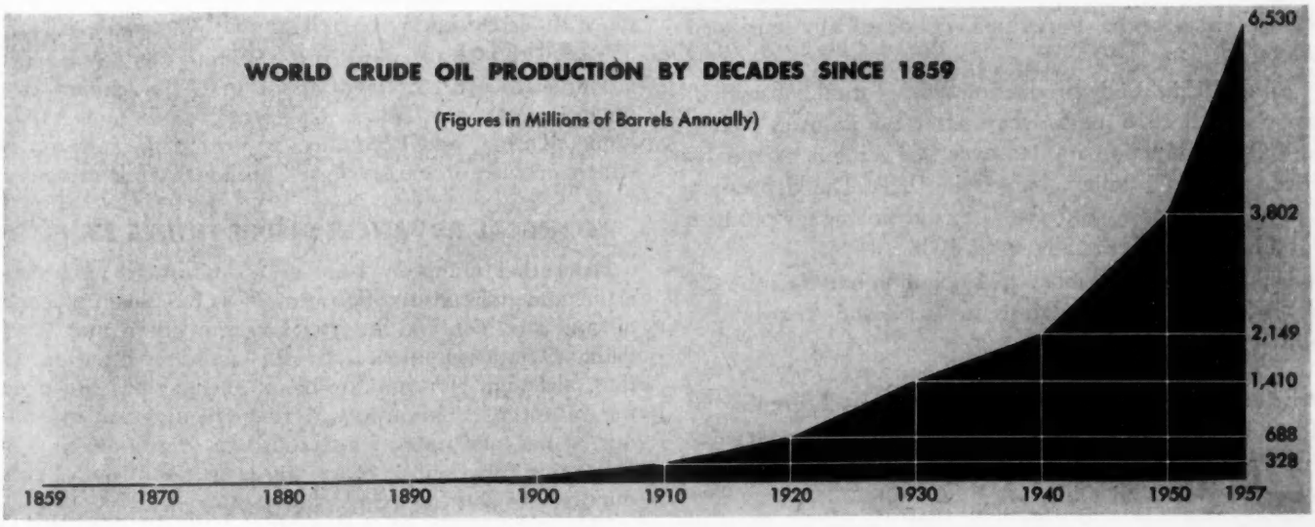
Percent of World Crude Oil Production Furnished by Principal Areas During Last Four Decades

Area	1957	1947	1937	1927	1917
United States	40.1	61.4	62.7	71.3	66.6
Venezuela	15.5	14.4	9.1	5.0	.....
U. S. S. R.	8.7	6.2	9.5	6.1	12.5
Middle East	19.8	10.1	5.7	3.2	1.4
Other Countries	15.9	7.9	13.0	14.4	19.5

Shift away from United States. With the exception of the years 1898 to 1902, when Russia held a small lead, the United States has been the largest oil producing country in the world. In 1957, U.S. production totaled 2.6 billion barrels. Venezuela, the second ranking country, produced only 1 billion barrels, while Russia was producing 800 million barrels. No other country produces more than 500 million barrels per year.

However, a complete transformation has taken place in the world's crude oil picture during the past decade. Although the United States still produces far more oil than any other single nation, the United States no longer holds the dominating position it held in the past. Oil operations in the rest of the world have been expanding faster than in the U.S. during the last 10 years. Particularly large gains have occurred in the Middle East countries and in Venezuela.

Whereas the United States produced 71 percent of the



world's oil in 1927, its portion declined to just over 60 percent during the decade between 1937 and 1947. Despite continued growth in U.S. production, by 1957 the United States produced only 40 percent of the world's oil production.

In contrast, Venezuela's contribution to total world crude oil production rose from 5 percent in 1927 to over 15 percent in 1957. Meanwhile, the output of Middle East nations climbed from 3 percent of the world's total in 1927 to 6 percent by 1947, and to nearly 20 percent by 1957.

Operations span the globe. Today, oil is produced in every continent. Fifty-six different nations produce crude oil in varying amounts, with exploratory and drilling operations conducted in many additional countries.

Up until 1900, there were only 11 countries producing oil. This rose to 25 by 1925, and to 45 by 1945.

United States participation abroad. U.S. companies participate strongly in the oil activity outside of the U.S. It has been estimated that U.S. companies own nearly 60 percent of the Free World's known unproduced crude oil reserves located outside the United States.

During the oil shortage scare following World War I, U.S. interests began to look abroad for oil. In doing so, they were supported by the State Department's advocation of an open door policy. With the discovery of numerous prolific U.S. fields in the late 1920s and during the 1930s, several of the companies dropped their concessions abroad. Consequently, at the end of World War II, only 28 U.S. oil companies were operating abroad.

Today, almost 200 U.S. companies own interests in concessions outside this country. Most of these companies also are domestic oil producers. Some of the companies are small independent producers, who have formed partnerships with others to be able financially to cope with the expense of operating abroad.

U.S. PRODUCTION STILL IS GROWING

Since Drake's discovery 100 years ago, the United States had produced approximately 60 billion barrels of oil. Yet, its production in recent years has been larger than ever before, despite the imposition of drastically curtailed producing rates.

Annual U.S. crude production did not total 300 million barrels until 1916, or 57 years after the industry's birth in 1859. Production rose to over 500 million barrels by 1922, then to 1 billion barrels in 1929. The depression caused a decrease, and the U.S. did not again produce 1 billion barrels annually until 1936.

U.S. production climbed to 1½ billion barrels annually by 1943, to 2 billion barrels in 1948, and to over 2½ billion barrels in 1956.

Production widely scattered. From its beginning at Titusville in 1859, U.S. oil production spread across western Pennsylvania into the nearby states of New York, West Virginia and Ohio.

By 1900, substantial production also existed in California, and modest amounts were being produced in Texas and Colorado. Small production existed in Oklahoma, Kansas, Wyoming, Kentucky, and Tennessee.

Production in Pennsylvania continued to increase, reaching 30 million barrels during 1882. Output declined until discovery of the McDonald pool in 1890 boosted the state's output to an all-time high of 31 million barrels in 1891. Pennsylvania today is still producing 8 million barrels per year, most of it due to secondary recovery activity.

Pennsylvania was the leading producing state from 1859 until 1895. Ohio's production had been growing rapidly since 1886, and swift development of the Lima region enabled it to become the leading producing state in 1895. It held this rank until 1903. Ohio's peak production was 22 million barrels in 1900. During 1957, Ohio produced 5 million barrels of oil, a comeback from less than 3 million barrels 10 years previously.

From 1903 to 1915, California was the leading producing state. Oklahoma lead from 1916 through 1922. California again was the leading producer during 1923 to 1927.

Oklahoma's production reached a peak of 255 million barrels during 1929, when the Seminole area was chief contributor. The state's production declined to 123 million barrels in 1943, but in recent years again has been above 200 million barrels annually.

California became the first state to produce 100,000 barrels per day in 1919, and also was the first to produce 200,000 barrels a day. The latter was achieved in 1923. California's output reached a peak of 365 million barrels in 1953.

Texas leads. In the middle 1920s, Texas came forward with a rush. Its production of 257 million barrels by 1928 was the greatest in the nation. Continuous significant discoveries since that time, including the famed East Texas field in 1930, has kept Texas at the top of the producing column. Texas' production reached 500 million barrels in 1941, then 800 million barrels in 1947, and more than one billion barrels annually by 1951.

Today, 30 states produce oil and gas in varying amounts. In order of their importance, the leading producing states are Texas, California, Louisiana, Oklahoma, Kansas, and Wyoming. These are the only states which produce in excess of 100 million barrels annually.

TECHNICAL ADVANCES INSURE FUTURE SUPPLY

Few other industries have been confronted with such a phenomenal consumption growth as has taken place in oil and gas. Yet, the industry has more than met every demand imposed upon it by the consuming public. In fact, although consumption of oil and gas has grown at the fastest pace in history during recent years, the industry has performed its discovery, development and producing functions so efficiently large quantities of production are shut-in today.

The preceding discussion of the industry's first 100 years has pointed repeatedly to the important role technological advances have played in providing the world with an abundantly supply of oil and gas. Certainly, technology has proved to be the great multiplier of the world's oil and gas resources.

Tremendous technological advances in finding, drilling and producing methods have been instrumental in making possible the industry's phenomenal production gains. Were it not for the great scientific strides of the past 30 years, the supply of petroleum undoubtedly would not be sufficient to satisfy the huge quantities being consumed today.

Scientific techniques promise an adequate supply of petroleum for many, many future years. Engineering progress is undergoing faster advancement today than ever before. Already, scientific progress is bringing the dream of synthetic and substitute liquid fuels closer to realization. There no longer is any doubt that petroleum can be made from shales, coal and other sources.

It is a comfort to know these substitute sources are available, if and when needed. It is equally comforting to realize the tremendous strides made in petroleum technology during recent years, and how much these advances have meant in supplying the peoples of the world with oil.

Huge future needs. The industry is confronted with a gigantic task in providing sufficient oil for future needs. Various forecasts have predicted the world will be consuming 1½ billion more barrels annually within five years. Finding, development and the production of so much oil constitute a greater challenge to the industry's ability and ingenuity than ever before.

The greatest deterrent to continued expansion of the petroleum industry is the possibility that future economic and political conditions may not provide worthwhile financial returns for risk capital and individual enterprise.

The peoples of the United States and elsewhere must come to appreciate that only the hope of individual reward moves human beings to real creative and productive effort, or to risk their savings in such hazardous activities as are involved in the discovery and production of oil. Consequently, an open door to opportunity must be maintained so energetic men willing to take risks can hope for adequate rewards. Otherwise, man's initiative, ingenuity, energy, and courage will be stifled.

If given these conditions, enterprising companies and engineers will provide the world with an abundant supply of petroleum for many years to come, despite anticipated rapid increases in consuming rates. —**The End**

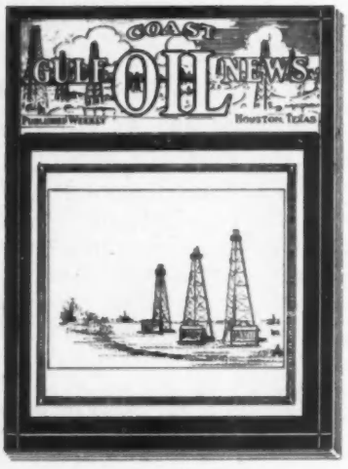
From 1916 to 1959

WORLD OIL'S Colorful History Spans Almost Half Century of Achievement

OIL'S 100th Anniversary 1859-1959

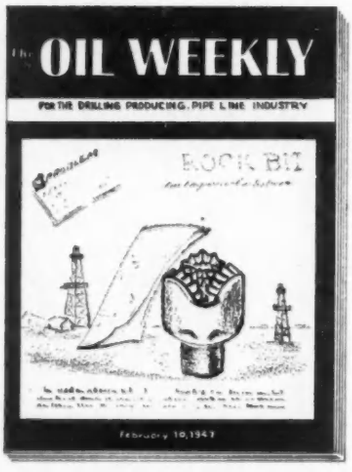
Growing with the industry it serves, WORLD OIL is one of the end results of a publishing plan that was formulated 43 years ago.

In 1916 a young newspaper man named Ray L. Dudley became associated with a new weekly oil magazine called the *Gulf Coast Oil News,* published in Houston. This publication was devoted mostly to covering fast-moving oil developments of those hectic days. Daily newspapers then did not report in depth on oil country happenings, and the *Gulf Coast Oil News* served that purpose. Its name was changed to the *Oil Weekly* in April, 1918, in order to allow for wider geographical coverage.



1916

The *Oil Weekly* struggled through the war year of 1918 and survived the depression years of the early twenties. It was, even in those days of exaggeration and superlatives, always a conservative paper. It was founded on private capital and individual initiative, and all through the years its management believed in honesty and fair play. During its history it built a reputation for dependability, originality and initiative. It was usually there "fustest with the mostest." Ray L. Dudley was president and publisher.



1947

The *Oil Weekly* became specialized for the Production division of the industry in 1922. A refining publication was started in 1922, and another specialized publication was created for the pipe line business in 1954.

As time went by, daily newspapers began covering the oil industry adequately. Editorial policy of the *Oil Weekly* was gradually changed. In place of news reporting, it started covering the latest engineering-operating developments.

The *Oil Weekly* veered its editorial direction to parallel the many advancements in technology.

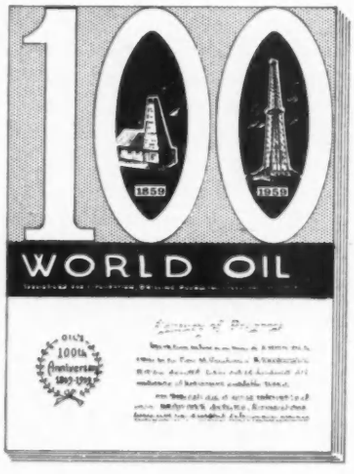
Through the 1930's and 1940's, spurred by World War II, achievements in techniques and equipment were remarkable. The *Oil Weekly* faithfully reported these developments to its readers. Its aim was to help subscribers drill for, produce and transport oil and gas more efficiently through use of the latest engineering-operating information.

By 1947 it became evident that weekly oil reporting magazines no longer attracted their once thorough readership. Busy oil men had insufficient time to read four or five copies of a publication every month.

The *Oil Weekly* was changed to a monthly. Even more engineering-operating features were offered, in one comprehensive, monthly, easy-to-read package. The new name, WORLD OIL, was chosen, to show the increased scope of the publication.

In the past 12 years WORLD OIL has grown in influence, importance and circulation. With more than 25,000 subscribers, it is the world's leading publication for the exploration-drilling-production phases of the oil industry. In that period, total circulation has increased 56%; engineer subscribers have increased 119%; superintendents, 51%; and foremen, 154%. Wherever oil is sought or produced, WORLD OIL has subscribers. It is truly international.

Ray L. Dudley passed on to a well-deserved rest in 1957. But his foresight and integrity remain as a rich heritage to the present management team of WORLD OIL. The company has become the world's largest specialized oil industry publishing firm. Total combined circulation of its three oil publications exceeds 52,500. It is backed by a million dollar printing plant.



1959

The past is a portent of good things for the future. Plans for the next 43 years . . . and the next 100 years . . . call for even greater growth and service to the industry. That industry's progress will continue to be mirrored in its leading publication —WORLD OIL. This is symbolized in the "Century of Oil" issue you are now reading.

Determining recoverable gas reserves

This method of calculating gas reserves is rapid and relatively simple. Reasonably accurate predictions can result if basic reservoir data are known

By Dan H. McLendon
Lane-Wells Company
Dallas

RECOVERABLE GAS reserves can be determined, with a reasonable degree of accuracy, by certain calculations. They involve the reservoir volume and conditions, producing conditions and physical characteristics of the gas. If the reservoir being studied is of the expansion type, calculations are simplified. Unlike a water-drive reservoir (where the void volume is subject to reduction by encroaching water), the void volume of an expansion-type reservoir will not change during its producing life.

The term "volumetric" is used, because the problem is one of volumetric changes as determined by Boyle's and Charles' laws. As a further refinement, a correction for deviation from the perfect gas laws is achieved by using a compressibility factor.

The nomograph presented is for calculation of the recoverable gas reserves from a volumetric or expansion-type reservoir. To arrive at one continuous expression involving only multiplication and division operations, it was necessary to resort to algebraic substitutions. The classic formula does not lend itself to use in a nomograph. This one continuous expression is shown in the Gas Reserve Nomograph Data Sheet (Figure 1).

To determine reservoir volume, it is necessary to know the average effective porosity, gas saturation (or 1-water saturation), average thickness of the reservoir rock and productive area. The following formula then can be used:

$$V_r = 43{,}560 \times A \times h \times \phi \times S_g$$

where
V = reservoir volume in cubic feet
43,500 = factor to convert area in acres to square feet
A = producing area in acres
h = producing thickness in feet
ϕ = average effective porosity in percent
S_g = gas saturation in percent.

If certain factors are known, a simple equation which properly represents the PVT relationship of gases may be applied.[2,3,4] Factors that must be known are reservoir volume, reservoir pressure, reservoir temperature and the compressibility factor at reservoir conditions. The simple equation is:

$$PV = ZNRT$$

where
P = pressure is psi
V = volume in cubic feet
Z = compressibility factor
N = number of pound moles, or

$$\frac{\text{lb. wt.}}{\text{mol. wt.}}$$

R = 10.73 for all gases
T = absolute temperature, degrees Rankine

Since N and R do not change, they can be eliminated from the equation as constants. The equation then becomes

$$PV = ZT$$

Now, from Boyle's and Charles' laws, gas at reservoir conditions and standard conditions can be related:

$$\frac{P_r}{Z_r}\frac{V_r}{T_r} = \frac{P_s}{Z_s}\frac{V_s}{T_s}$$

(where r and s refer to reservoir and standard conditions, respectively).

Solving for V_s gives the volume of gas present in the reservoir in cubic feet at standard conditions. Since gas

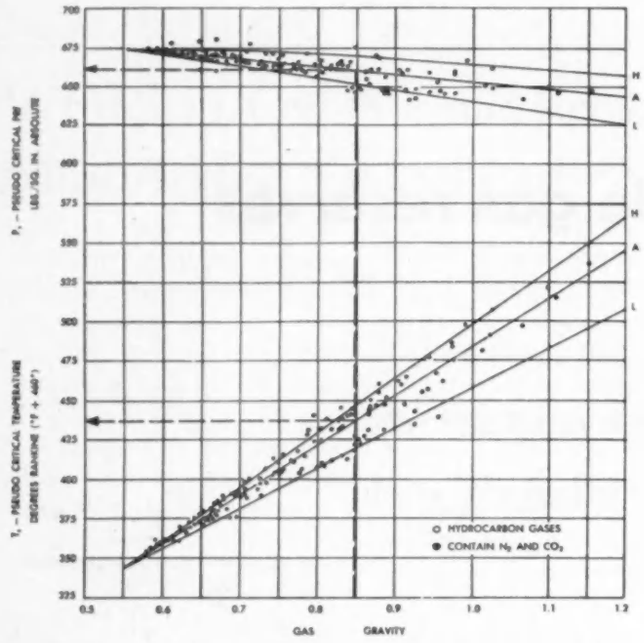


FIGURE 1—The Pseudo Critical Properties Chart is illustrated. The chart is used to determine the pseudo critical temperature and pressure of the gas under consideration. After P_c and T_c have been determined, the pseudo reduced properties of the gas can be calculated.

reserves are expressed in these terms, the amount recoverable can be determined by either of two ways:

- A recovery factor can be applied to V_g.
- The standard volume of gas remaining in the reservoir at abandonment conditions can be determined and this volume subtracted from V_g.

A nomograph calculation determines the volume of the reservoir in cubic feet (V_r). Then, the gas volume at reservoir conditions is converted to standard conditions (V_g) Finally, at abandonment conditions, there is always a portion of gas left in the reservoir. Also, this must be expressed in terms of cubic feet at standard conditions (V_a). This volume subtracted from the standard volume at reservoir conditions is the amount producible to abandonment conditions.

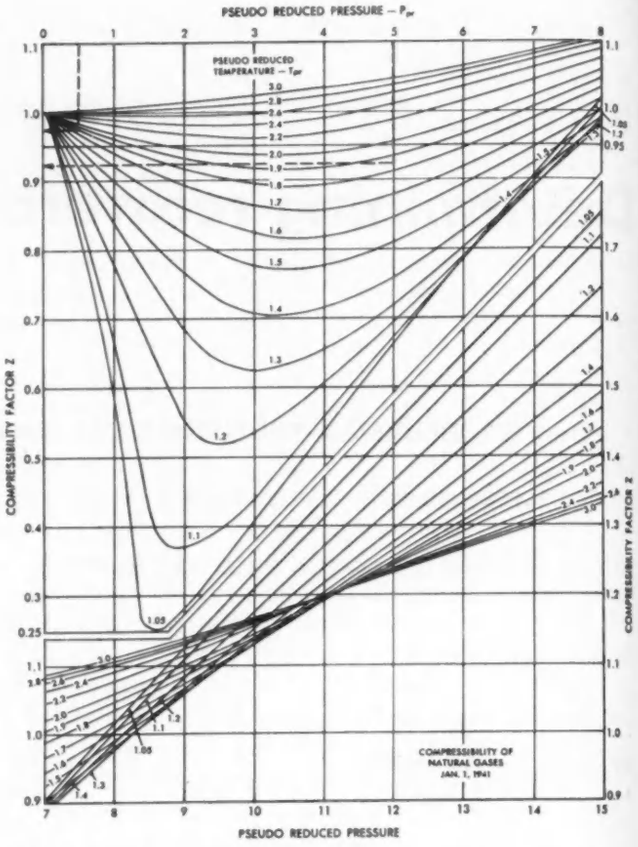
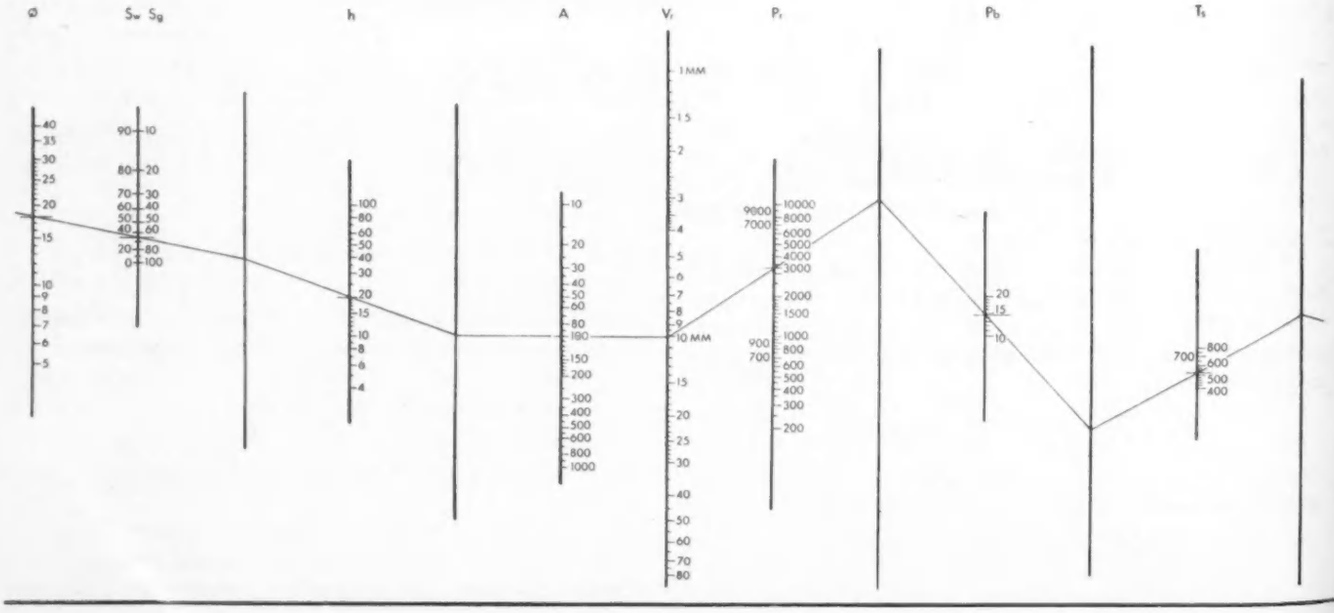

PSEUDO REDUCED PRESSURE – P_{pr}
PSEUDO REDUCED TEMPERATURE – T_{pr}
COMPRESSIBILITY FACTOR Z
COMPRESSIBILITY OF NATURAL GASES JAN. 1, 1941
PSEUDO REDUCED PRESSURE

FIGURE 2—A compressibility chart for natural gases is shown. The value of Z_r (compressibility factor under reservoir conditions) can be found from the chart once the pseudo reduced critical properties of the gas have been calculated. Z_a may be found in a like manner.

EXAMPLE: A 100-acre lease has 20-feet of gas sand with 18 percent porosity and 65 percent gas saturation. Reservoir temperature is 350° F., reservoir pressure is 3,300 psi. Specific gravity of the gas is 0.85. The pipeline will take no lower than 250-psi gas, so this will be considered abandonment pressure. Standard temperature is 60° F.;



standard pressure is 14.7 psi and atmospheric pressure is 13.5 psi. The problem is to determine the amount of standard gas producible to abandonment conditions.

(To facilitate solving for the compressibility factors, two charts are included, as Figures 1 and 2. Both are taken from the "Natural Gasoline Supply Men's Association Engineering Data Book," pages 82 and 83.)

Enter all known data on the gas reserve nomograph data sheet, as shown. To determine Z_r, use the Pseudo Critical Properties Chart (Figure 1). First enter at gas gravity 0.85, read up to the average line of the lower set of curves, and then read horizontally to the left to $T_c = 437$. Next, enter at the same specific gravity (0.85), read up to the average line of the upper set of curves, and then read horizontally to the left to $P_c = 662$.

The Pseudo Reduced Temperature and Pressure are then determined as follows:

$$T_{pr} = \frac{460 + 350}{437} = 1.85$$

$$P_{pr} = \frac{3300 + 13.5}{662} = 5.01$$

Using the Compressibility Chart (Figure 2), enter at $P_{pr} = 5.01$, read down to $T_{pr} = 1.85$, and then read horizontally to the left to $Z_r = 0.92$.

The value $Z_a = 0.975$ is determined in the same manner.

Enter the values from the Data Sheet into the nomograph and correct the points, working from left to right. Values for V_r, V_s, and V_a are entered on the Data Sheet as shown. By subtraction, recoverable gas reserve = 1,495 MM cubic feet. This represents a recovery of 92 percent, which is, perhaps, high. If a recovery factor of 85 percent had been used, the average would be 1,380 MM cubic feet.

REFERENCES

[1] Calculation of Gas Reserves, Engineering Fundamentals, *Oil & Gas Journal*, 1953, p.53.

[2] Buthod, Paul, "Compressibility Factors of Natural Gases," *Oil & Gas Journal*, September 8, 1949, p. 79.

[3] Natural Gasoline Supply Men's Association Engineering Data Book, 1951, pp. 77-82.

[4] Pirson, S. J., Elements of Oil Reservoir Engineering, 1950, p. 223.

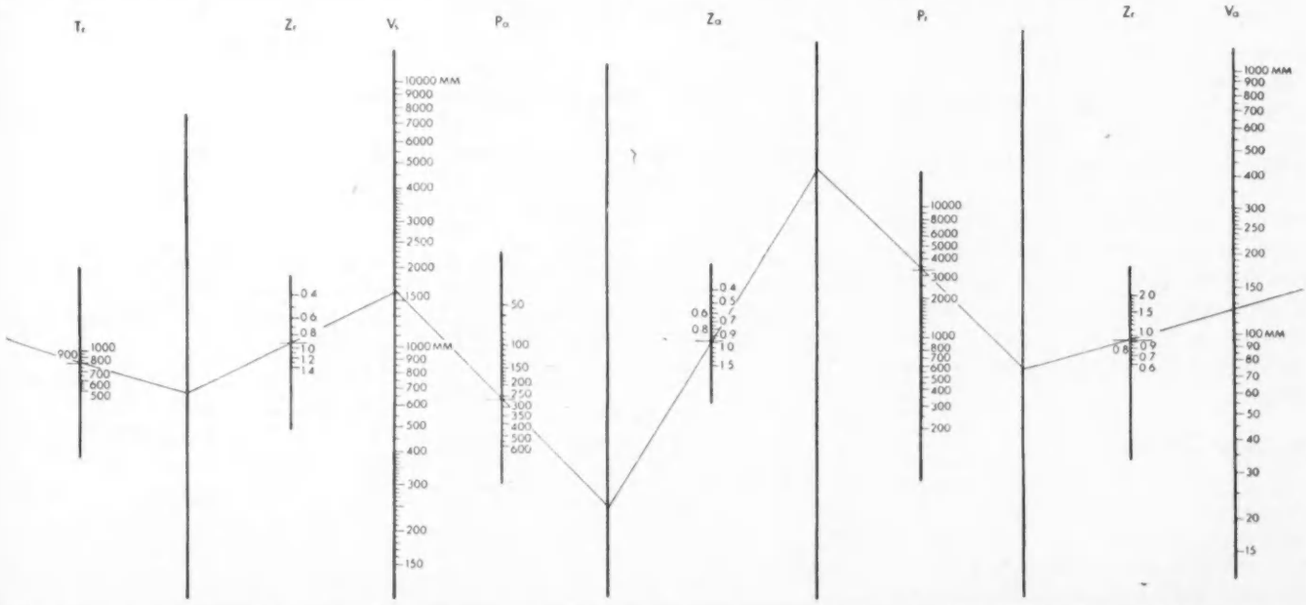
[5] The Law of Perfect Gases, Engineering Fundamentals, *Oil & Gas Journal*, 1953, p. 51.

$$\phi \times S_g\ (\times 43{,}560) \times h \times A\ (=V_r) \times P_r \times \frac{1}{P_b} \times T_s \times \frac{1}{T_r} \times \frac{1}{Z_r}\ (=V_s) \times P_a \times \frac{1}{P_r} \times \frac{1}{Z_a} \times Z_r\ (=V_a)$$

LEGEND

ϕ — Porosity in % 18.0	P_r — Reservoir Pressure (gage) in psi 3300 + P_g = ... 3313.5
S_g — Gas Saturation in % 65.0	T_r — Reservoir Temperature in °F 350 + 460 = ... 810 °R.
S_w — Water Saturation in % 35.0	T_s — Standard Temperature in °F 60 + 460 = ... 520 °R.
h — Producing Thickness in ft. 20	Z_r — Compressibility Factor at Reservoir Conditions 0.925
A — Area in acres 100	Z_a — Compressibility Factor at Abandonment Conditions .. 0.975
Specific Gravity of Gas at Atmospheric Pressure 0.85	V_r — Reservoir Volume (void) in cu. ft. ..... 10.1 MM
P_b — Standard Pressure Base in psi 14.7	V_s — Standard Gas Volume at Reservoir Conditions, cu. ft. 1620.0 MM
P_g — Atmospheric Pressure in psi 13.5	V_a — Standard Gas Volume at Abandonment Conditions, cu. ft. 125.0 MM
P_a — Abandonment Pressure (gage) in psi 250 + P_g = .. 263.5	$V_s - V_a$ = Recoverable Gas Reserve, cu. ft. ..... 1495.0 MM

FIGURE 3—Once the basic reservoir characteristics have been determined, the gas reserve nomograph may be used to determine actual reservoir volumes. The data sheet illustrated should be used in all determinations for simplicity.



Know your . . .

Fuels for high-speed diesel engines

For best operating results and longer part life, well-refined, completely distilled and non-corrosive fuel oils should be used

By E. J. Godlew
Staff Engineer, Detroit Diesel Engine Division
General Motors Corporation
Detroit

DURING THE past 30 years, diesel engines have undergone an evolution from the original heavy, low-speed stationary and marine prototypes to the light-weight, high-speed power plants used wherever work in terms of horsepower is required. Whether it be in the classification of stationary, semi-stationary or otherwise portable power, the high-speed diesel engine has firmly established its reputation for reasons of economy, ruggedness and long life. The term high-speed diesel engines refers to those that usually operate between 1,200 and 3,000 rpm and used in such applications as circulating pumps, draw-works, well servicing and completion units, trucks, air compressors, etc.

The old adage that "diesel engines will burn anything" is just as true as for these small-bore, high-speed engines as for their cumbersome ancestors. High-speed engines can be operated on lubricating oils, vegetable and animal oils, or the variety of fuel oils referred to as "diesel oils." But their digestive tract is of necessity more sensitive than that of large bore low-speed engines, and for best operating results and longest life the high-speed diesel engine requires fuel oils which are completely distilled, well-refined and non-corrosive to the fuel system parts.

Variety of fuels. The quality of fuel oil can be a dominating factor for satisfactory engine life and performance. A large variety of fuel oils are marketed for diesel engine use by the petroleum industry. Their properties will depend upon the refining practices and the nature of the crude oils from which they were produced. Fuel oils, for example, may be produced within the boiling range of 300° F. to 750° F., having many possible combinations of properties.

Much has been said about fuel oil, the pros and cons of various grades and their effects on diesel engine operation. To understand why one fuel may be more satisfactory than another, it is necessary to know the three most important properties of diesel engine fuel oil:

- Boiling range
- Cetane rating
- Sulfur content

For complete combustion, all liquid fuels first must be vaporized. The boiling temperature of a fuel is also the temperature at which it is vaporized. Because of this, the boiling range of fuel oil should be low enough to permit complete vaporization at the existing engine temperatures. Since the combustion chamber temperature is dependent on the ambient temperature, engine speed and load, incomplete vaporization is apt to occur particularly during cold weather and/or light load operation.

As a result, for engines operating at reduced speeds and loads or in cold weather (low compression temperatures), lower boiling point fuels will give more satisfactory performance. Fuel that cannot be completely vaporized and burned will accumulate and form sludge and other harmful deposits in the engine.

Effect of cetane number. To insure proper spontaneous ignition, the ignition quality (cetane number) of the fuel must be sufficiently high. When the cetane number of the fuel is too low, it may result in difficult starting, engine knock and white exhaust smoke, particularly during engine warm up and light load operation when engine temperatures are very low. If these conditions are allowed to exist, harmful fuel deposits will accumulate within the engine.

Diesel fuels are classified according to this American Society for Testing Materials fuel classification D 975-49T. Grade 1D fuels range from kerosine to intermediate distillates. Grade 2D has progressively higher boiling points, while Grade 4D does not specify the distillation.

Grade of Diesel Fuel Oil	Cetane Number (Min.)	Sulfur % by Wt. (Max.)	Distillation Temperatures, ° F.		Viscosity at 100° F, Kinematic Centistokes (or SUS)	
			90% Boiling Point (Max.)	100% Boiling Point (Max.)	(Min.)	(Max.)
No. 1-D	40	0.50	...	625	1.4	.....
No. 2-D	40	1.0	675	...	1.8 (32.0)	5.8 (45)
No. 4-D	30	2.0	...	...	5.8 (45)	26.4 (125)

This safe fuel guide applies to most high-speed diesel engines . . .

Type of Engine Application	Ambient Air Temperature	Distillation		Cetane Number (Min.)	Sulfur Content (Max.)
		90% Boiling Point (Max.)	or Final Boiling Point (Max.)		
Wide variation in load and speed, considerable idling.	Above —20°F	550°F	575°F	45	0.25%
	Above 0°F	575°F	625°F	45	0.50%
	Above +40°F	575°F	625°F	45	0.50%
	Above +80°F	625°F	675°F	40	0.50%
Intermediate load and speed, minimum idling.	Above —20°F	550°F	575°F	45	0.25%
	Above 0°F	575°F	625°F	45	0.50%
	Above +40°F	625°F	675°F	40	0.50%
	Above +80°F	625°F	675°F	40	0.50%
Heavy load and high speed, minimum idling.	Above —20°F	575°F	625°F	45	0.50%
	Above 0°F	625°F	675°F	40	0.50%
	Above +40°F	625°F	675°F	40	0.50%
	Above +80°F	675°F	725°F	40	1.00%

The influence of cetane numbers is not independent of other fuel properties and, therefore, it alone is not a guarantee against deposit formation.

To minimize deposit formation, the sulfur content of the fuel must be as low as possible. Limited amounts can be tolerated, but there is a direct relationship between the amount of sulfur present in fuel and the amount of corrosion and deposit formation within the engine. Impartial tests have shown that increasing sulfur content from 0.25 percent to 1.25 percent increased deposits and wear 135 percent. This action usually is most pronounced on the cylinder liners, pistons and rings.

While the boiling range, cetane rating and sulfur content are the most important properties of fuel oil, there are other factors which should be mentioned. Viscosity measures a fuel oil's internal resistance to flow. Fuel should be able to flow freely at the lowest temperature expected. Water and the contaminants which accompany it usually result in corrosion and wear in fuel injection systems. Well refined oils rarely contain more than a trace of ash. Larger amounts indicate contamination by dirt and sand which result in an abrasive action on the moving parts in the engine. The amount of ash present in fuel oil should be kept to a minimum.

Pour point is the temperature at which fuel stops flowing. For cold weather operation, the pour point should be specified 10° F. below the ambient temperature at which the engine is to be operated, except where fuel or oil heating facilities are provided. Cloud point measures the temperature at which wax crystals start to separate from the fuel. This should be below the lowest temperatures encountered to prevent clogging of fuel filters.

Powdered coal blown into the cylinder by compressed air was the first fuel used in a diesel engine. Today, the preference is, of course, for petroleum products with the types of fuels available for use in diesels varying from light fuels such as kerosine to heavy distillates. Recently, other types have been added to this list. These include some of the jet and turbine type fuels and, in many cases, furnace oils.

Operations vary. How well a diesel engine can operate with these different types of fuel is another matter. Successful operation will vary from one fuel to another, depending upon a great many factors.

Only in rare instances are high rpm diesel engines continuously operated at, or even near, their rated maximum speed and load capabilities. Mud pump engines, as an example, may operate for a considerable time at idle during trip time, then immediately swing up to top speed and load to effect final penetration. These variations in speed and load result in a variation in the temperature of the combustion chamber of the engine. Like a human being, the faster and harder an engine works, the warmer it gets. The slower it works, the cooler.

The temperature of the outside air used in the engine has an effect upon compression temperatures. An engine operating at the North Pole in an ambient temperature of 20 degrees below zero will have lower compression temperatures than one operating on the Equator in an ambient temperature of 100° F. All the above

Continued on Page 226

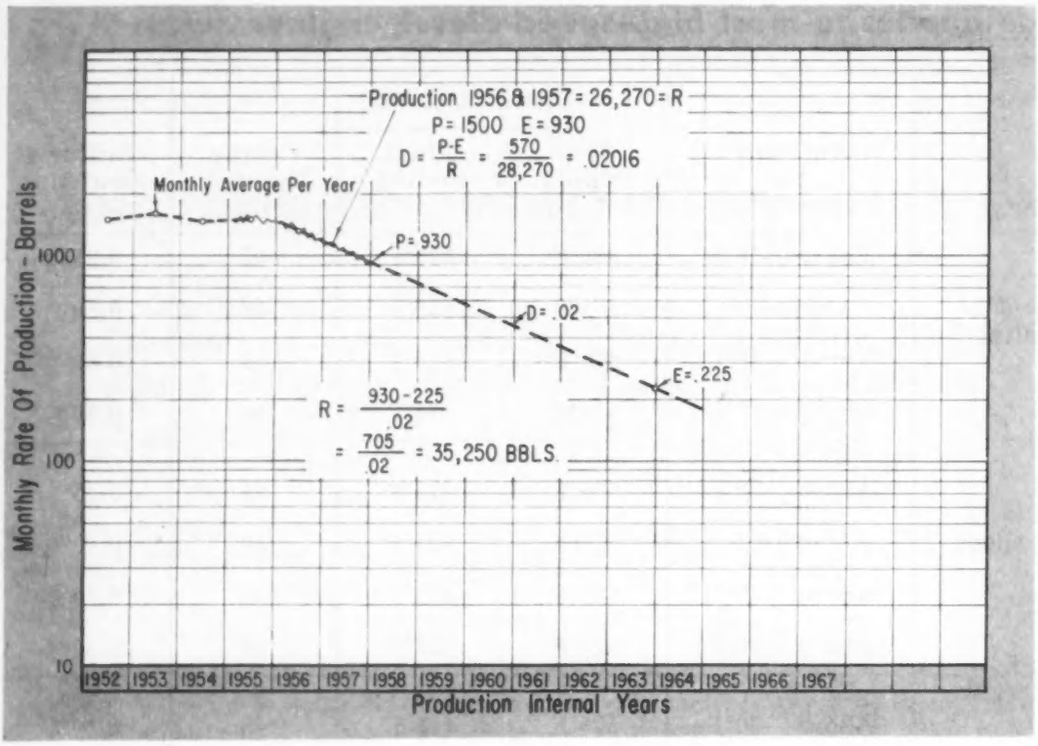


FIGURE 1—Production history curve showing method of calculating decline rate.

Expedite reserve estimates with . . .

Semilogarithmic decline curves

By Robert I. Bradley
Petroleum Engineer, Tulsa

DECLINE CURVES of oil production, where applicable, are widely used as a means for estimating oil reserves. The semilogarithmic decline curve is probably the most popular type of the several kinds used because it is simple to prepare and easy to use. However, the application of this type of decline curve to estimates of reserves and certain economic problems would be further simplified if there were means available for accurately determining the percentage of decline and the time element involved in each case. It is the purpose of this discussion to present simple aids for determining these particular factors.

The semilogarithmic decline curve is prepared by plotting monthly production in barrels on the vertical or logarithmic scale versus time in months on the horizontal scale, as shown in Figure 1. In an outstanding number of instances, production for a well or lease will decline at a constant percentage rate. The decline for these cases appears as a straight line sloping downward and to the right. It is this particular feature which lends to the simplicity in determining reserves from this type of decline curve, since a straight line is much easier to extrapolate than is a curve.

Limitations which apply to other types of decline curves also are applicable to semilogarithmic decline curves. It is the basic assumption in all cases that conditions which applied in the past also will be effective to the same degree in the future. A change which affects producing conditions in any manner will alter the decline trend established under ideal operating conditions. None of the types of decline curves are applicable for reserve estimates during the period when production is curtailed by proration.

Basic formulas applicable. The five principal factors contained in the basic formulas applicable to semilogarithmic curves are, as follows:

- R reserves, or future production, in barrels
- P current monthly rate of production, in barrels
- E monthly rate at terminal period, in barrels
- D decline per month, percentage expressed as a decimal
- n time of period applicable, in years and months

If the reserves to depletion are required, E will be the monthly rate at the economic limit of production, or the rate after which the lease no longer returns a profit from the operations.

By using geometric progressions, the

Experience is necessary for a proper future production forecast

following basic formulas may be determined:

$$R = \frac{P - E}{D} \quad (1)$$

$$D = \frac{P - E}{R} \quad (2)$$

$$n = \frac{\log P/E}{\log (1 - D)} \quad (3)$$

Determination of percentage decline. In calculating reserves or future production for Formula (1), the current production is known, the economic limit or terminal rate of production may be calculated or estimated, but the decline rate must be determined from the curve itself. It is possible to calculate the decline by using Formula (2), but a known recovery for a definite period preceding the date of estimate must be known. However, there are occasions when this recovery is not readily available, and there are also cases when it is important to accurately construct a definite decline curve, particularly if a forecast of production is required.

A method for determining the percentage decline per month by means of a prepared calculator for semilogarithmic curves was described by Arps.[1] This calculator must be prepared for the particular kind of semilogarithmic paper used in the plot, and it has the disadvantage of not being applicable to another kind of paper with a different scale.

To simplify the determination of a decline shown on a particular curve or to construct a definite decline, a method is proposed which is based on readings for different decline rates at the end of the fifth and tenth years in the semilogarithmic plot.

Figure 2 shows a chart, prepared on 20-year, three-cycle semilogarithmic paper, which is commonly used in decline curves. The lines on this chart represent monthly declines of different rates originating in the upper lefthand corner. These were constructed by using compound discount tables for 100 years and plotting annual figures as months after the manner suggested by Gross[2] in his article on this subject.

Readings for the intersection of each decline on the vertical lines which represent the end of the fifth and the tenth years are included in Table 1. These readings were tabulated with 100 representing the top or uppermost horizontal line of the logarithmic scale, and 0.1 representing the bottom or base line of the paper.

To apply these data in determining the percentage of decline, place a large triangle along the straight line and its extrapolation. Using another triangle for a guide, slip the first triangle upward until its edge intersects the upper lefthand corner of the semilogarithmic paper in use. The reading on the fifth or tenth year is observed, and the percentage decline is read from Table 1. If a definite percentage decline is desired, place the first triangle so that its edge passes through the initial point in the upper lefthand corner and the reading for the fifth or tenth year corresponding to the percentage decline in Table 1. Then, using a guide triangle, the first triangle may be slipped downward to the current or starting production. A set of parallel rules, such as used in navigation, may be substituted for the two triangles.

This method can be applied to any size or scale of semilogarithmic paper. After repeated use, the readings corresponding to declines commonly encountered are easily remembered.

TABLE 1

Percent Decline Per Month	Reading at End of Year		Percent Decline Per Month	Reading at End of Year	
	5th Year	10th Year		5th Year	10th Year
.5	73.0	54.0	2.6	21.5	4.60
.6	70.0	48.0	2.7	20.0	4.10
.7	66.0	43.0	2.8	19.0	3.60
.8	62.0	38.5	2.9	18.0	3.20
.9	59.0	34.0	3.0	17.0	2.85
1.0	55.0	30.4	3.1	16.0	2.60
1.1	52.0	27.0	3.2	15.5	2.35
1.15	51.0	28.0	3.3	14.5	2.10
1.2	49.0	24.0	3.4	14.0	1.95
1.25	48.0	22.5	3.5	13.0	1.75
1.3	46.5	21.5	3.6	12.5	1.52
1.4	44.0	19.0	3.7	11.8	1.38
1.5	41.0	17.0	3.8	11.0	1.21
1.6	39.0	15.0	3.9	10.5	1.09
1.7	37.0	13.5	4.0	9.6	.95
1.8	34.5	11.8	4.5	7.0	.50
1.9	32.5	10.5	5.0	5.3	.29
2.0	30.5	9.3	5.5	4.0	.17
2.1	29.0	8.4	6.0	2.95	....
2.2	27.5	7.4	6.5	2.25	....
2.3	26.0	6.6	7.0	1.75	....
2.4	24.0	5.9	7.5	1.30	....
2.5	22.8	5.2	8.0	.97	....

Preparation of forecasts. Engineers often are required to prepare a forecast of future production for reserves estimated by volumetric means. This condition exists during the early part of the producing history when proration is effective.

A forecast can be prepared by judicious use of available history of older but comparable wells in the general area. Changes in capacities of individual wells on the lease under consideration are carefully examined. This experience, combined with the knowledge of the current allowables and the ability of older but comparable wells to make their allowable, may serve as a basis for estimating the duration of constant production under proration for the lease under consideration. The decline after the period of constant production is usually based upon the experience of the older leases. Needless to say, production experience and judgment on the part of the engineer are requirements for using this type of procedure on forecasts of this nature.

Determination of future time. The future time corresponding to the period involved in an estimate may be determined directly from the extrapolation of the decline curve, or may be calculated from Formula (3). However, there are certain economic problems which would be expedited in their solution if the time element could be directly determined without resort to these methods.

Figure 3 can be constructed by using Formula (3) or by reference to Figure 2. It is apparent that the time is a function of the decline rate for constant ratios of P/E. This chart is useful in economic studies and for determining the future life in estimates of reserves and

Figures 2 and 3 on Pages 222 and 223
Text continued on Page 226

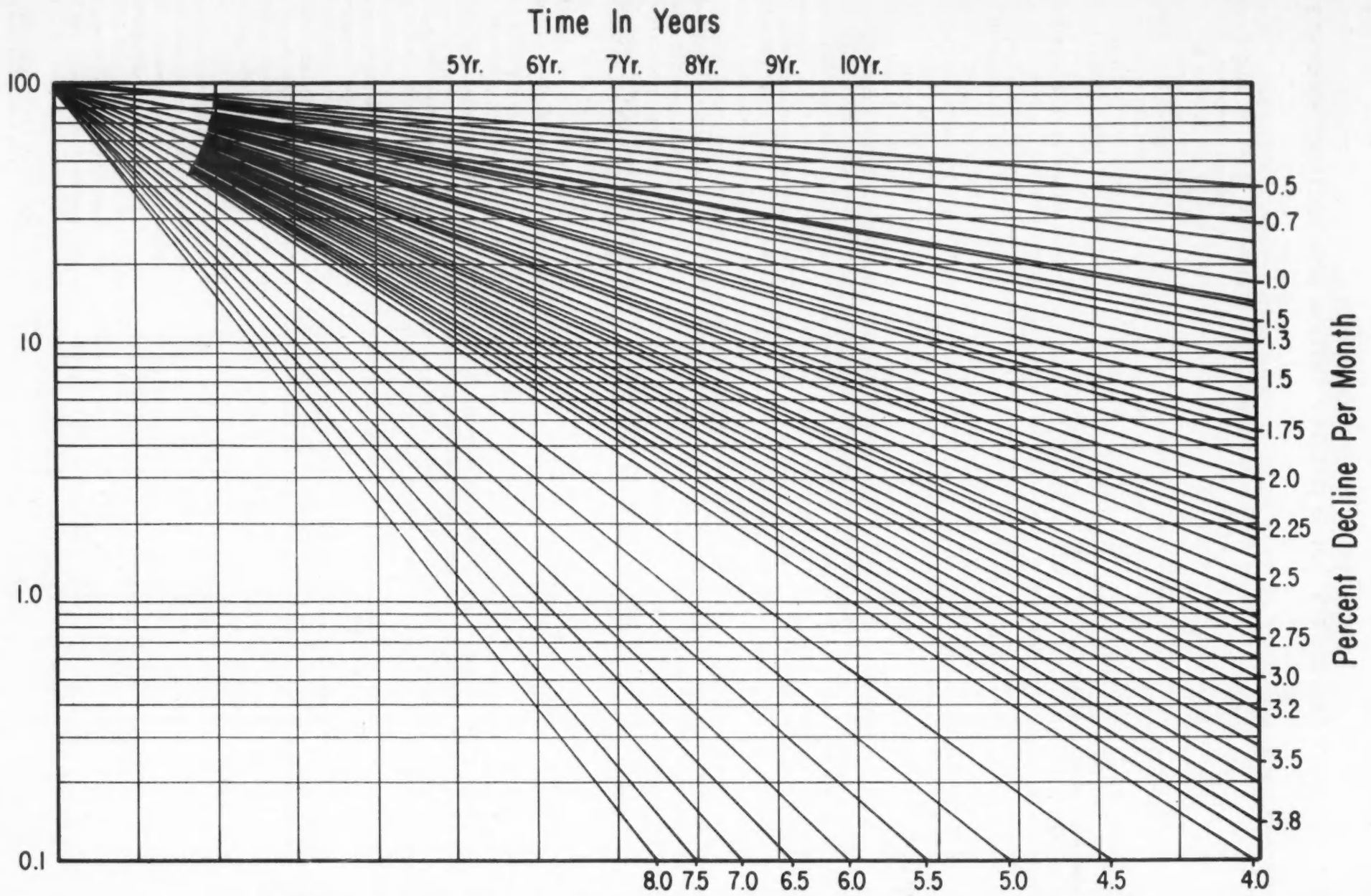


FIGURE 2—The lines on this chart represent monthly declines of different rates originating in the upper left hand corner.

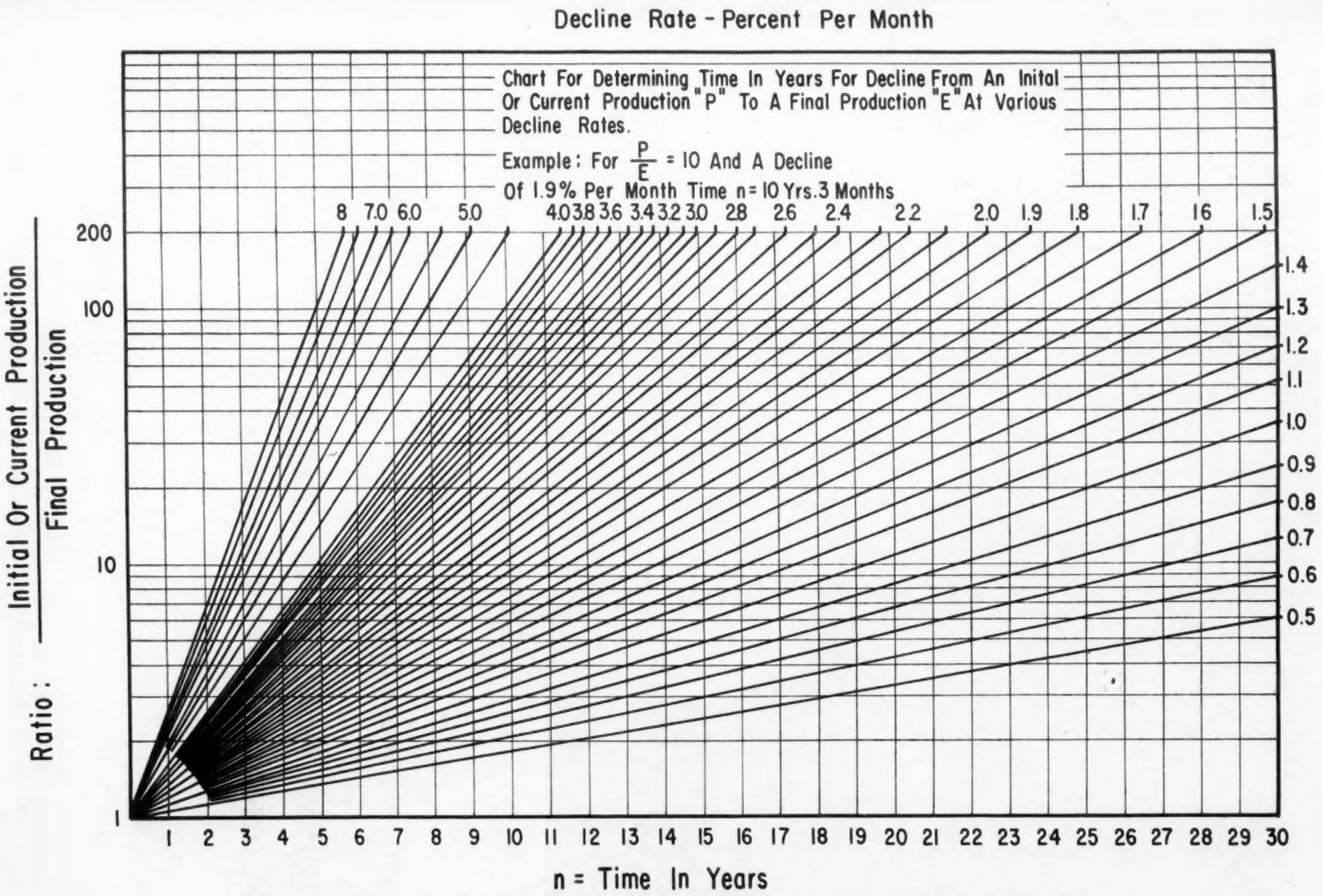

Decline Rate - Percent Per Month
Chart For Determining Time In Years For Decline From An Inital Or Current Production "P" To A Final Production "E" At Various Decline Rates.
Example: For P/E = 10 And A Decline Of 1.9% Per Month Time n= 10 Yrs. 3 Months
8 7.0 6.0 5.0 4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6 2.4 2.2 2.0 1.9 1.8 1.7 1.6 1.5
1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5
Ratio: Initial Or Current Production / Final Production
200 100 10 1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
n = Time In Years

FIGURE 3—This chart permits direct reading of the future time for problems involving semilogarithmic decline curves.

This air drilling rig is operating in the Hogshooter field, Washington County, Oklahoma, for The Carter Oil Company. Eighteen shallow producing and water injection wells were drilled to extend a water-flood project.

In water-flood operations . . .

Shallow hole air drilling technique proves successful

By S. N. Stearns, Engineer
The Carter Oil Company, Seminole, Okla.

THE CARTER OIL COMPANY'S application of air drilling on a contract footage basis has proved highly successful in drilling shallow wells in the Hogshooter field, Oklahoma, where a water-flood development program was completed in a relatively short time. The technique proved successful despite volumes of water up to 100 barrels per day which were encountered, and which so often hinder air drilling operations. Drilling costs were reduced and successful coring operations performed. In addition, the drilling contractor's costs were decreased by improved penetration rates and increased bit life.

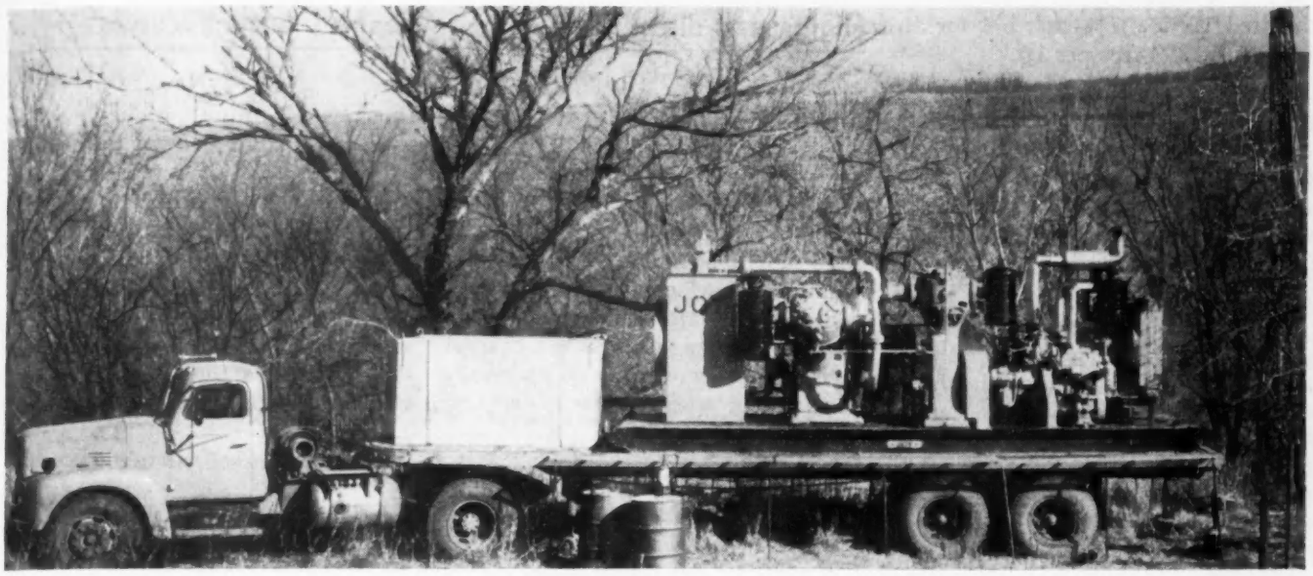
Since the latter part of 1954, Carter has drilled several wells in "hard rock" areas utilizing a gaseous circulating medium. It was generally believed that this drilling technique was most applicable in areas of high drilling cost where zones produce little or no water.

In 1957 application of air drilling was considered in the Hogshooter field, in Washington County, Oklahoma, and competitive air drilling bids were received. As a rapid development was desired at this time, contracts for drilling 18 shallow wells by air were awarded. The wells were intended as an extension of a water flood project where the productive zone is the Pennsylvanian Bartlesville Sand, encountered from 1,050 to 1,200 feet. Drilling in the area is described as medium to good with very little sharp abrasive formations.

Equipment. Drilling was accomplished with a small portable rotary rig equipped with a 58-foot derrick, a small mud pump and a pull-down assembly.

A kelly seal fabricated by the drilling contractor was attached to the rotary table to divert cuttings away from the rig. As the rotary table opening was only 7½ inches, the seal assembly was constructed to allow changing of bits and subs below the table. The tapered drilling string which was used consisted of 2⅞-inch full hole and 3½-inch internal flush pipe. A 25-foot by 3½-inch kelly with a 2½-inch internal diameter, and three 5-inch drill collars were used.

The contractor furnished piston type compressors rated at 600 cfm at 125 psig., powered by diesel engines with a fuel consumption of 10 gallons per hour each. Normally, two compressors were used, although mechanical failures resulted in the use of one compressor in some instances. Three wells were drilled utilizing a single V-type positive displacement compressor rated at 1,050 cfm at 150 psig. This unit was powered by twin diesel engines and fuel consumption



Portable compressor unit used in drilling three shallow wells by air for Carter in the Hogshooter field. The technique proved highly successful in reducing drilling time and costs.

was 15 gallons per hour. This portable unit is shown above.

The air supply line connecting the compressors to the standpipe at the rig was 3-inch aluminum pipe.

Performance. In this application of shallow hole air drilling, a total of 20,308 feet of hole was penetrated below the surface pipe. Eighteen wells, including 10 injection wells, were drilled to depths ranging from 1,078 feet to 1,190 feet. Approximately 20 feet of 8¾-inch surface hole were drilled and 7-inch casing was set.

After attaching the rotating kelly seal assembly to the surface pipe, air drilling operations using 6¼-inch bits commenced. A small water producing sand was encountered at approximately 200 feet in each well which did not hinder drilling operations. The Oswego Limestone at 700 feet produced from 20 to 100 barrels of water per day. In some wells, the water flow from this zone was reduced by making fast connections and increasing the penetration rate by adding weight to the bit.

Apparently, the flow of air reduced the flow of water by exerting a back pressure on the formation, and the shale cuttings blown past the zone formed a "mud cake" which would hold for 10 to 15 minutes after shutting down the air compressors. Every effort was made to prevent downtime after penetrating these water producing zones. Once a well started making water that could not be reduced, the normal rotary speed of 60 to 80 rpm was reduced to 45 rpm and approximately two barrels of water were pumped down the drill pipe each 20 to 40 feet to clean the bit.

After total depth was reached, 4½-inch casing was cemented, and the rig was immediately moved to another location. The time required to move from one location to another and rig up rotary tools ranged from 2½ hours to 8½ hours and averaged 6 hours per well. These wells were drilled on 10-acre spacing.

The total rotating time on bottom, below the surface pipe, required to drill the 18 wells, was 537 hours, for an average of 29.8 hours per well.

TABLE 1

	Air Drilled Wells	Mud Drilled Wells	Cable Tool Drilled Wells
Number of Wells Drilled	18	4	6
Total Footage	20,903	4,270	6,340
Footage Below Surface Pipe	20,308	4,203	6,053
Per Well Average:			
From Surface:			
Total Depth (Avg. Feet)	1,156	1,068	1,057
Total Rig Time (Hours)	46.4	127.6	192.3
Overall Penetration Rate (Ft/Hour)	24.9	8.3	5.5
From Below Surface Pipe:			
Average Footage (Small Hole)	1,128	1,051	1,009
Rotating Time (Hours)	29.8	105.4	.....
Penetration Rate Ft/Hour	37.8	10.0	.....
Average Number of Bits	1.3	3.0	.....
Size Bits Below Surface (Inches)	6¼	7⅞	8 and 6
Hours Per Bit	23.3	35.1	.....
Feet Per Bit	882	350	.....
Average Weight on Bit	9,000	6,500	.....
Rotary Speed (RPM)	70	85	.....

This was a penetration rate of 37.8 feet per hour.

Total drilling time from spudding until casing was cemented was 835.2 hours or an average of 46.4 hours per well.

One well was air drilled from below surface pipe to total depth in 21.5 rotating hours.

Six wells in the pool were cable tool drilled during the same water-flood expansion. As a comparison, the total drilling time from spudding until casing was set averaged 192.3 hours per well for a penetration rate of 5.5 feet per hour.

Four wells were rotary mud drilled within the water-flood area during 1955, and the penetration rate below surface pipe averaged 10 feet per hour.

A more detailed comparison of performance is supplied in Table 1.

Bit performance in the air drilling operations was exceptionally good. One 8¾-inch retipped bit was used to drill 18 surface holes, or approximately 495 feet. Thirteen new 6¼-inch bits were used to drill one well each for an average of 1,133 feet per bit. Ten 6¼-inch retipped bits were used to drill the remaining five wells. The new bits saved an average of seven hours drilling time per well over wells drilled with retipped bits. Mud drilling four wells in the pool

required 12 new 7⅜-inch bits for an average of 350 feet per bit.

One of the most advantageous uses of air as a circulating medium was for diamond coring. Prior to air coring two wells in the Hogshooter field, chip coring with cable tools was generally used. The procedure used in air coring differed very little from conventional mud coring.

Before coring operations could begin, the core barrel was lowered to a point near the bottom of the hole, and the water which had accumulated in 2½ hours was blown out. Air was circulated at a rate of 1,200 cubic feet per minute with a standpipe pressure of 125 psig. Coring began on top of the Bartlesville Sand at 1,156 feet with 4,000 pounds weight on the bit, and the weight was increased to 7,000 pounds at 1,159 feet. Rotary speed ranged from 48 to 60 rpm during coring operations. Total time required to penetrate 23 feet of Bartlesville sand and 5 feet of shale including two round trips with the core barrel was 5 hours and 12 minutes. Actual rotating coring time required was 2 hours and 10 minutes. Core recovery was 100 percent.

Air drilling footage costs were slightly lower than cable tool footage costs during the same period. Contract footage rates for rotary mud drilling were comparable to the air drilling footage costs. Although slight savings were realized in the actual drilling costs, of more importance were the benefits realized from completion methods made possible by air drilling, coring techniques and the decreased supervision. The total over-all savings amounted to approximately $400 per well.

About the Author

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High-speed diesel fuel

Continued from Page 219

engine operating conditions that effect compression temperatures should be considered when determining what type of fuel to use.

It should be pointed out that all high-rpm diesel engines can satisfactorily burn a wider range of fuels than the accompanying chart shows. Special fuels are not required by an nationally known high rpm diesel engine.

Good rule. A good rule to follow is: Use the fuel that best suits the application and which gives the most satisfactory operation.

It often is stated that engine design determines the type of fuel to use. This is a false assumption.

One of the most frequent claims by some engine manufacturers is that pre-combustion chamber design permits engines to use lower grades of fuels. Cooperative studies made by the Petroleum Industry and Engine Manufacturers showed similarity in agreement that an increase in sulfur content resulted in an increase inn engine deposits and wear in both pre-combustion chamber engines and open combustion chamber engines. An increase in volatility had the same effect.

These examples only emphasize that fuel contaminants will have a detrimental effect and can cause harmful deposits to form in one engine as well as another.

When selecting a fuel oil, each engine owner should consider the economics of using cheaper fuels, that is whether it pays to use the so called lower grade fuels instead of the better distilled grades. The money saved on fuel costs with these lower grade fuels may be offset by additional maintenance more frequent overhauls and the use of high priced higher detergent lubricating oils. If the engine owner finds that for his application he is able to realize a savings by using the cheaper fuels, then by all means he should do so.

Where better fuels may not be obtained conveniently, higher detergency lubricating oils can be used to help counteract sludge formation and lube oil contamination or reduce the oil drain period which will effectively minimize the varnish and sludge deposits encountered in service.

—The End

Semilog decline curves

Continued from Page 221

forecasts of future production. This may be illustrated by an example:

Suppose that it has been determined that 100,000 gross barrels are required to retire an oil payment applicable to a certain lease. The allowable is 50 barrels daily or about 18,000 barrels per year. Past experience shows that the wells produce at their allowable for a period of one year and then decline at the rate of 1.5 percent per month. The payout time is determined, as follows:

$$R = 100{,}000 - 18{,}000 = 82{,}000 \text{ barrels}$$

$$82{,}000 = \frac{P - E}{.015} = \frac{1500 - E}{.015}$$

$$E = 1500 - 82{,}000 \times .015 = 270$$

$$P/E = \frac{1500}{270} = 5.6$$

by reference to Figure 3, n = 9 years and 6 months for the period of decline, or the total time to retire the oil payment is 10 years, 6 months. Substituting values in Formula (3), n is determined mathematically to be 9.58 months for the period on decline.

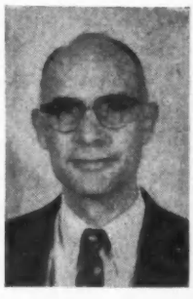
Adoption of the aids outlined in the discussion will assist and expedite the application of semilogarithmic type decline curves to estimates of reserves and other economic problems encountered by the petroleum engineer.

REFERENCES

[1] Analysis of Decline Curves, J. J. Arps, Petroleum Development and Technology, A.I.M.E., 1945, P. 228.

[2] Decline Curve Analysis, Henry Emmett Gross, Oil and Gas Journal, Sept. 15, 1938, P. 55.

About the Author



Robert I. Bradley, petroleum engineer, Tulsa, specializes in appraisals of oil and gas properties, estimates of oil and gas reserves and geological and engineering studies. A graduate of the University of California, his first oil field job was with the former Gypsy Oil Co., now Gulf Oil Corporation. He has worked as petroleum production engineer for the Wilcox Oil Co. and Grimes Gasoline Company. Before becoming a consultant, he worked 11 years for Keplinger and Wanenmacher of Tulsa, as senior petroleum engineer.

Studies of ancient beaches provide clues in oil search

Ancient shore lines deserve detailed investigation since they are a source of clean sand with good permeability and are interstratified with potential oil forming environment

By Prof. Warren C. Thompson
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Boulder

STUDIES OF THE petroliferous Permian Lyons sandstone where it outcrops on the west side of the Denver Basin, indicate the lamination, cross-bedding, truncating surfaces, texture, mineral composition, stratigraphic relations and facies changes compare significantly with similar features in modern beaches.

Although this article is limited to a regional study, the results may be applied to any area where it is desirable to study ancient beaches and their influence on oil accumulation. This conclusion is based on findings which show, in general, that shore processes localize areas of clean sand with good permeability. Hence, recognition of ancient beaches becomes a device for localizing oil accumulation.

Four commercial oil fields (Black Hollow, New Winsor, Pierce and Fort Collins) produce from the Lyons sandstone of Middle Permian Age (Figure 1).

Ancient beach. Quarries at Lyons, Colo., the type locality of the formation, make possible detailed observations of the original structures. Comparison of these original structures with those of modern beaches on the California coast indicates that the Lyons sandstone is an ancient beach.

Most beaches are laminated. Laminae are comprised of uniformly-sorted layers of sand, each a few millimeters thick. Light materials such as quartz and feldspar predominate. These materials alternate with a thin lamina of dark, heavy minerals (magnetite, zircon, garnet, etc.) of greater specific gravity than quartz and feldspar. This arrangement results from wave activity. Under normal conditions, a few laminae are added daily to the seaward slope of the beach. Grain size of the lighter laminae reflects the carrying power of specific waves. Abrupt changes in grain size from lamina to lamina reflect changes in wave strength, but uniform sorting within individual laminae remains.

The dark, interstratified laminae of heavy minerals form in response to winnowing out of lighter material incident to the backwash of one wave and the swash of the next succeeding wave. In places, this winnowing process is repeated several times with no addition of light materials but with resulting concentration of the heavy, dark laminae (Figure 2).

In laminae of the Lyons sandstone, the sorting arrangment just described prevails. However, the intervening dark, heavy mineral laminae are not apparent. Apparently relatively few heavy minerals were available for concentration at the time of deposition or they were dissolved in the long interval since Permian time.

Wave activity. In most places modern shores experience tidal changes which raise and lower the water level twice daily. Moreover, such shore lines experience high and low tides in the course of a year. Such changes in sea level are called high-high and low-low tides. When intensive storms develop concurrently with high-high tides, there is considerable removal of previously deposited laminated sand. One such storm on the California coast cut a scarp 11 feet high and 160 feet landward from the mean-tide shore line during a single tidal change. The wedge of beach sand removed was carried offshore, where the sea remained discolored by suspended sand for several days. With the resumption of normal wave activity, sand laminae reaccumulated on the much-flattened beach surface 80 feet landward from the mean sea-level shore line. The nearly flat, sea-

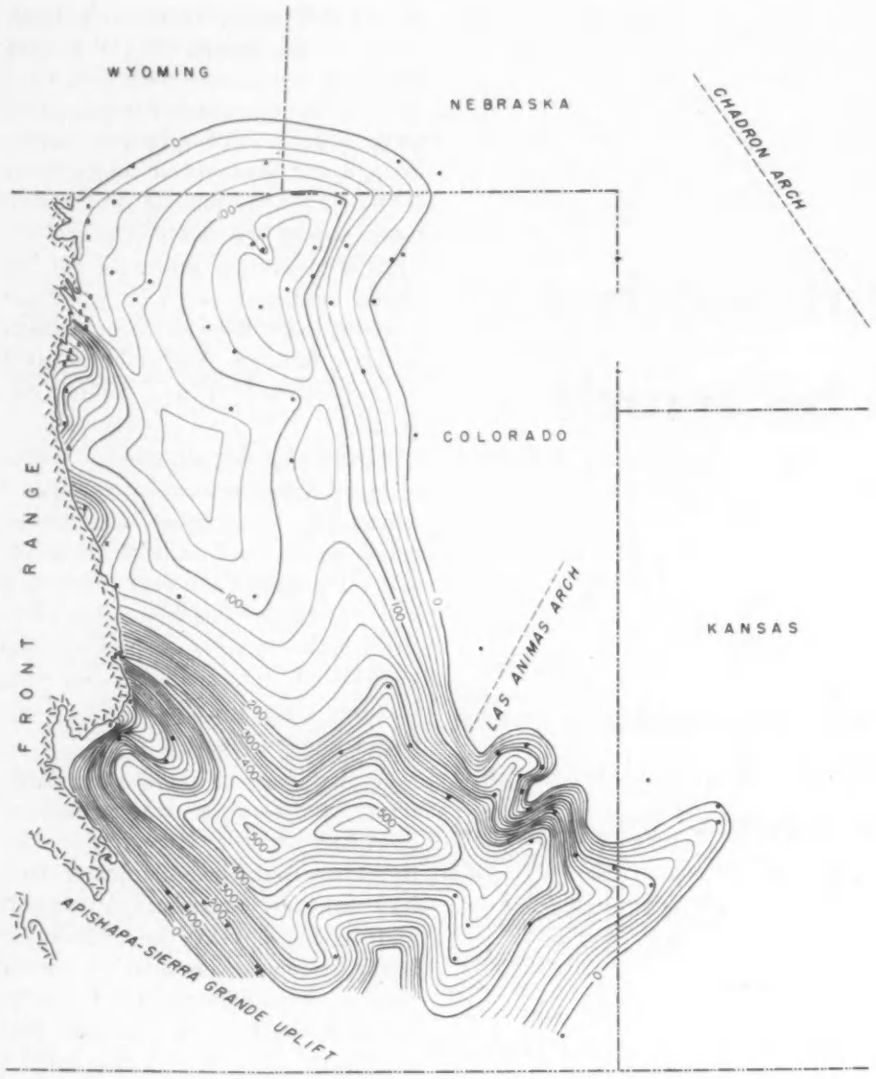

FIGURE 1—Here is an isopachous map of the Permian Lyons sandstone in the Denver Basin. The Lyons is a body of cross-bedded, quartzose sand underlying approximately 30,000 square miles of the Denver Basin in Colorado, Wyoming and Kansas. The formation crops out along the west side of the basin for approximately 100 miles, but wedges out in the basin to the north, east and southwest. The northernmost outcrop of the Lyons wedges out between red siltstone below and a complex of red siltstone, evaporite and carbonate above. The southernmost outcrop is overlain and underlain by arkosic sand. Southward, the Lyons gradually becomes merged with this arkosic sand, until identification as a distinct sedimentary unit no longer is possible.

ward-sloping, storm-cut surface served as the floor of deposition for the redeposited laminae. The angle of seaward dip of the redeposited laminae was less than that of the previously deposited seaward-dipping laminae, the upper parts of which had been truncated by the storm-cut surface. The resulting cross-bedded structure (laminae with strikes parallel to the shore line but with small differences in seaward dip) commonly characterizes the internal structure of modern beaches. A similar original structure characterizes the Lyons sandstone.

Complication of structures. In places where beach cusps develop on modern shores, the cross-bedded structure described is complicated by addition of an element of dip parallel to the shore line. This occurs because the sides of the scoop-like embayments between beach cusps slope to the axis of the intervening trough. The trough is partly filled with laminated sand, fitted to the form of the embayment. Following storms, which truncate these previously-formed structures, the troughs of newly-developed, scoop-like embayments seldom coincide with those of pre-storm embayments. In the Lyons sandstone quarries scoop-like embayments corresponding in form and dimension to those of modern California beaches show similar complication of cross-bedded structures.

Modern beaches. On modern beaches of the California coast, a low ridge evolves along the shore as the bigger waves carry sand landward. With increased tidal height, some waves carry sand not only up the seaward-facing slope, but across the low ridge. The resultant sheet wash of sand-carrying wave water spreads the sand on the landward slope of the beach between the crest of the ridge and the coast line. The wave water thus isolated from the open sea forms a small, shallow stream which runs along the base of the slope at the back of the beach, seeking a way of return to the ocean.

When waves cross the crest of the beach, the process gradually increases the height of the beach and makes substantial, landward-dipping laminated additions to the back beach (Figure 3). The laminae added not only dip landward, but characteristically remain parallel-sided. In many places such laminae bury a previously-cut storm surface, below which the laminae may dip either landward or seaward. The resulting cross-bedded structure appears in the cross-sections of many modern beaches. Since strikes of involved laminae retain essential parallelism (places involving beach cusps excepted), the original structure is unique to beach sedimentation. Moreover, because this structure develops in response to high-high tides and to storm-produced, truncating surfaces, it lies well back on the beach with a chance of escaping erosion. Numerous former beach ridges (Chenier ridges) apparently formed in a similar manner, flank the Gulf Coast west of the Mississippi delta.

Even-bedded laminae. In the Lyons sandstone, even-bedded lam-

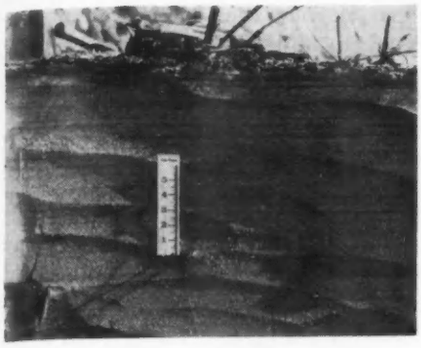

FIGURE 2—The dark, interstratified laminae of heavy minerals, shown in this beach sand, form in response to winnowing out of lighter material incidental to the backwash of one wave and the swash of the next succeeding wave.

inae, dipping westward away from the implied position of the ancient sea, form a substantial part of the total formation at the outcrop. Observations in one quarry at the type locality disclose two such groups delimited by prominent truncating surfaces. One of these structures, lying 150 feet eastward (seaward) from the other, has truncating surfaces such that the eastward (seaward) structure clearly is younger than the westward (landward) one (Figure 3). This arrangement implies a recession of the sea (probably temporary) because, in general, the Lyons sandstone overlies continental sediments and underlies marine sediments. This indicates regional transgression.

Minor features of deposition. Several less obvious minor features of deposition appear on both the surfaces of modern beaches and the bedded surfaces of the Lyons sandstone. *Lingoid Ripple Marks,* or backwash marks (Figure 4) appear in many places on modern beach surfaces as well as on slabs of Lyons sandstone. It is seen on both seaward- and landward-facing slabs of the Lyons.

Wave lines—minute thread-like sand ridges which delimit the landward periphery of the swash of a wave—overlap one another to produce a crudely-formed, scalloped pattern as the tide recedes. This feature, which is limited to the seaward face of the modern beach, also is a common feature of seaward-facing surfaces of the Lyons sandstone.

In many places minute hair-like, crudely-circular ridges of sand a few grains high surround shallow craters one-half to one inch in diameter on the surfaces of the even-bedded landward-dipping layers of Lyons sandstone. These shallow craters called bubble marks do not penetrate the lower surface but do leave a cast on the bottom of the overlying layer. This indicates that the craters form at the time of deposition of the sandstone. Significantly, air bubbling up through the water develops the shallow craters on modern beaches.

Shallow, scoured, flat-floored troughs, 15 to 20 inches wide, 1 to 2 inches deep, and many feet long, also appear on the back-beach part of the Lyons sandstone. In many places these troughs obliterate the bubble marks.

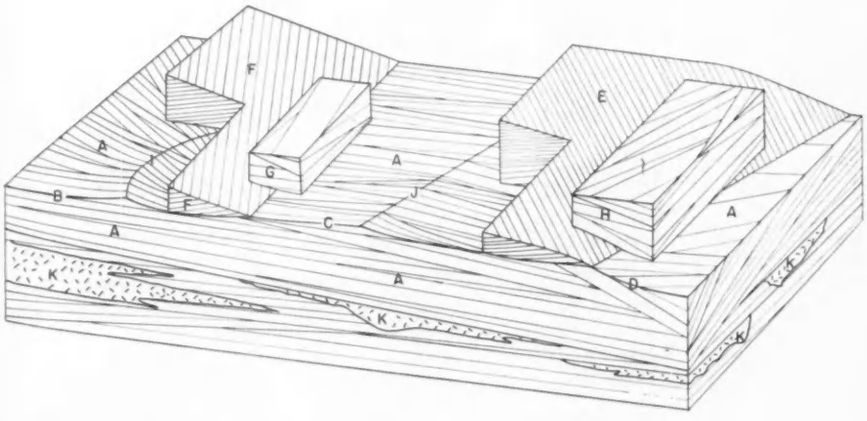

FIGURE 3—This block diagram shows relations of surfaces and laminae. Groups of southward-dipping, cross-bedded laminae A are truncated by surfaces B, C and D. Surface D also transects surface C and westward dipping laminae E, for which surface C is the floor of deposition. Similarly, surface C transects surface B and westward-dipping laminae F, for which surface B is the floor of deposition. Surfaces C and D act as floor of deposition for eastward-dipping laminae G and H. Curved surface I is one of several scoop-like embayments. Low ridge J discloses typical intersection between two surfaces that are not quite parallel. Arkose lenses K disclose buried channel structures near base of formation.

FIGURE 4—Lingoid ripple marks or backwash marks are a minor feature of deposition found on modern beaches and bedded surfaces of the Lyons sandstone. The pattern develops on surfaces over which thin layers of water have passed.

The troughs resemble those formed by wave water flowing along a modern back beach in its return to the sea after passing the crest of the beach. Courses of animal tracks frequently have been encountered in the quarrying of Lyons sandstone. Vertebrate paleontologists identify the track as one made by a marine reptile known as *Laoporus coloradensis* (Henderson).

Once the Lyons sandstone is established as an ancient beach, the features of its relationship with adjacent formations become significant and can be utilized as additional criteria for the recognition of other ancient beaches.

Arkosic lenses. At the type locality of the Lyons and for many miles to the south of this locality, the formation is interstratified (especially at the base) with numerous lenses of arkosic sandstone. In a few places such arkosic lenses appear not only many feet above the lowermost recognizable layer of quartzose Lyons sandstone, but in a few places actually overlies the Lyons sandstone. In every observed outcrop where a layer of arkose overlies one of quartzose sand, the contact is one of significant relief involving buried channels as a common feature. In many places only a small part of the quartzose sandstone layer remains. On the other hand, where quartzose sandstone overlies arkosic sandstone, the contact is smooth with virtually no relief whatever. The relationship implies that the agent depositing the quartzose sand was a "smoothing" one, as an advancing wave would be. On the other hand, the agent that deposited the arkose

was one characterized by "cut and fill" deposition, associated with fluvial activity.

The transition from fluvial conditions below to shore line conditions above involves numerous repetitions. At the southernmost extremity of recognizable Lyons outcrop, arkose sandstone simply overwhelms the quartzose sandstone so that it is known only in the subsurface, down-dip from the outcrop. The arrangement implies that the shore line was forced eastward by excessive arkose deposition.

Lyons sandstone wedge-out. At the type locality and southward, the Lyons sandstone is interstratified with the arkose of the underlying Fountain sandstone. North of the type locality along the outcrop, the Lyons sandstone thins rapidly to its wedge-out approximately at the Wyoming-Colorado state line. In this northern area the Lyons quartzose sandstone is separated from the underlying Fountain arkosic sandstone by a wedge of sediment consisting of fine-grained red mudstone, layers of carbonate and uniformly-sorted quartzose sand (Figure 5). This wedge, which gradually increases in thickness northward, comprises two formations: the Ingleside formation (which is the attenuated southern extremity of the Casper formation of Wyoming) and red muds of the Lower Satanka Tongue.

Since sand as coarse as that of the quartzose Lyons sandstone could not have been derived from the underlying red muds, it seems mandatory that the Lyons sandstone in northern Colorado comes from a remote source which could supply clean, reworked quartzose sand. The most obvious source for such material seems to be where the Ancestral Sierra Grande uplift merges with the south end of the Front Range (Figure 1). Although no recognizable Lyons sandstone crops out in this area, the excessive thickness of the Lyons in the basin northeast of the Sierra Grande uplift implies a nearby source. Laramide folding seems to have turned up the outcrop section west of the ancient shoreline.

One investigator has questioned whether or not a beach has ever had a chance to become part of the geologic record.[1] It was reasoned that, with transgression, the beach would be destroyed by advancing wave base. With regression, erosion would destroy the beach before it had a chance to be lithified. However, in the unique environment of the Lyons, preservation seems quite probable.

In late Pennsylvanian and early Permian time the south end of the basin to the east and northeast of the hinterland (the Ancestral Front Range and Sierra Grande uplift) must have been subsiding rapidly in order to permit deposition of the thick, arkosic sandstones of the Fountain formation. In most places this formation is composed of more than 1000 feet of fluvial sediment, all of which indicates deposition in shallow water. South of the type locality of the Lyons sandstone, the thickness of the Fountain formation increases steadily. Near Colorado Springs the Fountain is nearly 6000 feet thick. In such a tectonic environment, the Lyons sands seem to have subsided rapidly enough to escape erosion by wave base.

The southern end of the Ancestral Front Range and Sierra Grande uplift (which has been shown to be upper Pennsylvanian highlands[2]) was dumping much arkose into the basin. Waves seem to have reworked this material to form the thick, quartzose Lyons sands known in the deep part of the basin. A part of these sands drifted northward along the east side of the Permian Ancestral Front Range to form the beaches described. It is reasonable that these sands are interstratified with arkosic sand for several miles northward beyond the place

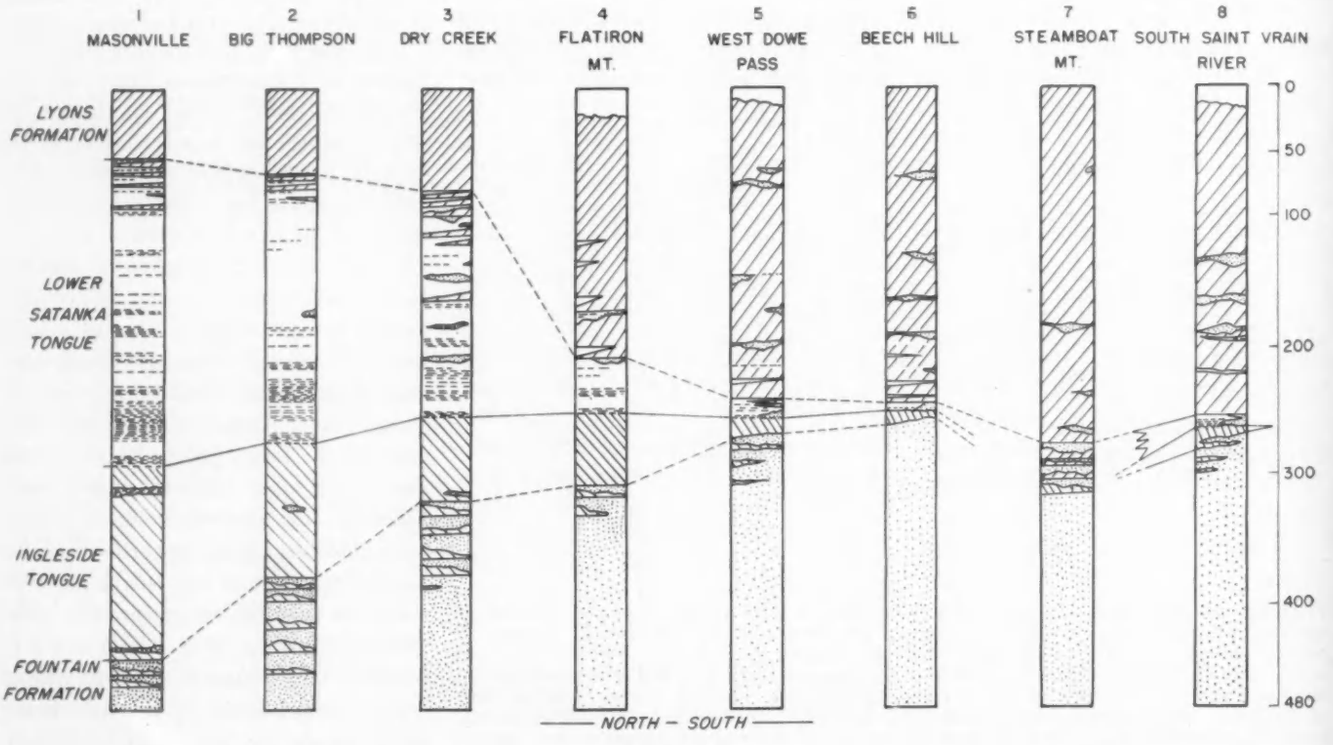

FIGURE 5—This chart shows the outcrop relations of Permian sediments from the Lyons type location northward.

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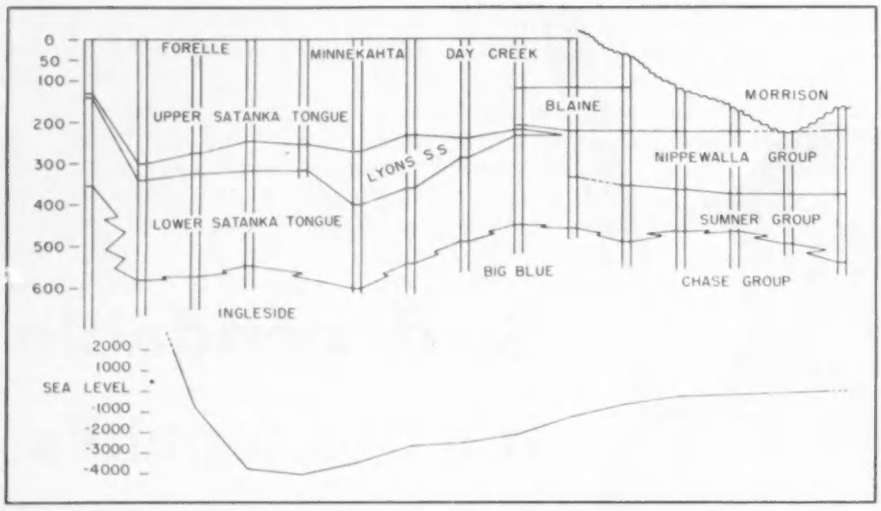

FIGURE 6—The relation of the Lyons sandstone to adjacent formations in the subsurface of the Denver Basin is shown here.

where Fountain arkosic sand is in contact with the base of the Lyons (Figure 5).

Consideration of beach structures. On modern shores, the lower foreshore (that part of the beach exposed only at low-low tide) is dominated by the activity of littoral currents. The upper foreshore is laminated by the activity of waves. The littoral currents of the lower foreshore move detritus in the same way that streams do. Hence sand bars with flat tops and steep sides move in the same direction as the current and steeply-dipping, foreset layers flank the down-current side of the bar. Small deltas are built into tidal pools by water seeping from the upper beach. Mica flakes are common constituents of the lower foreshore environment, in contrast to the almost complete absence of mica flakes in the upper part of the beach.

The Lyons sandstone, when traced northward from the type locality, seems to lose the well-defined beach structures described previously. Instead, it takes on the micaceous, short, foreset layers which characterize moving bars. A reasonable supposition is that a part of the northern end of the Lyons outcrop was deposited in shallow water some distance from the shore line. These sands were a part of the lower foreshore or perhaps even shelf sands.

When Laramide orogeny elevated the Colorado Front Range, the eastern margin of the uplift did not coincide exactly with the sinuous Permian shore line. Northward from the type locality, sediments at the outcrop display increasingly the characteristics of the lower foreshore beach or of shelf sands. The beach comparable to that seen at the type locality lay some distance west of the present outcrop.

Conversely, the area south of the type locality becomes increasingly involved with continental sediments, not only arkosic sands and conglomerates, but in many places with quartzose sands that lack the original structure of beaches.

Evaporites and Carbonates. The sequence of red mudstones, carbonates and evaporites that overlie the Lyons sandstone seems to have been the product of an ancient, restricted, hypersaline sea. Carbonates interstratified with red mudstones dominate the lower part of the section at the outcrop. Similar stratigraphic position involves only evaporites in the basin. Apparently the Permian hinterland furnished enough fresh water to dilute the sea near shore. For this reason, carbonate was deposited rather than evaporite. Many of these carbonate ledges contain "algal heads" which indicate that the water was fresh enough near shore for certain algae to survive.

Evaporites dominate even the surface-section sediments immediately above the Lyons in many sections of northern Colorado and at one point in the southern part of the state. A few Permian marine pelecypods appear in the carbonate layers. Traced eastward in the subsurface, the Lyons pinches out in an evaporite basin (Figure 6).

The general characteristics of these sediments imply marine conditions of deposition (although restrictive) in an almost certainly hypersaline sea. Since sediments below the Lyons are continental and those above are marine, the Lyons seems to have been the product of a marine transgression.

Any uniformly-sorted, sandy sediment which lies between continental and marine deposits is in the position across which a shore line must have passed and may be an ancient beach.

Dakota sandstones. Because the Dakota Group of sandstones overlies the continental Morrison formation and underlies Cretaceous Graneros marine shale, the suspicion that it is in part an ancient beach is tenable. In southern Colorado, the Dakota Group crops out in many places, as it does along the entire west side of the Denver Basin. In southern Colorado, original structures closely resembling those of the Lyons are to be seen in the nearly flat-lying Dakota sandstones. Subsurface studies in these sandstones in the Denver Basin disclose a compelling inference that there are ancient littoral formations here.

A sinuous belt in eastern Colorado, about 40 miles wide and many miles long, closely delineates the distribution of sand and hence oil production from the Dakota group. A low hinterland lay to the east, whereas a restricted basin in which black shales were deposited lay to the west of this sinuous littoral belt.

The position between continental and marine sediments, the presence of original structures resembling those of modern beaches and bars, and the close delineation of sand deposition within a sinuous linear belt all imply ancient littoral sediments, many of which probably were beach sands.

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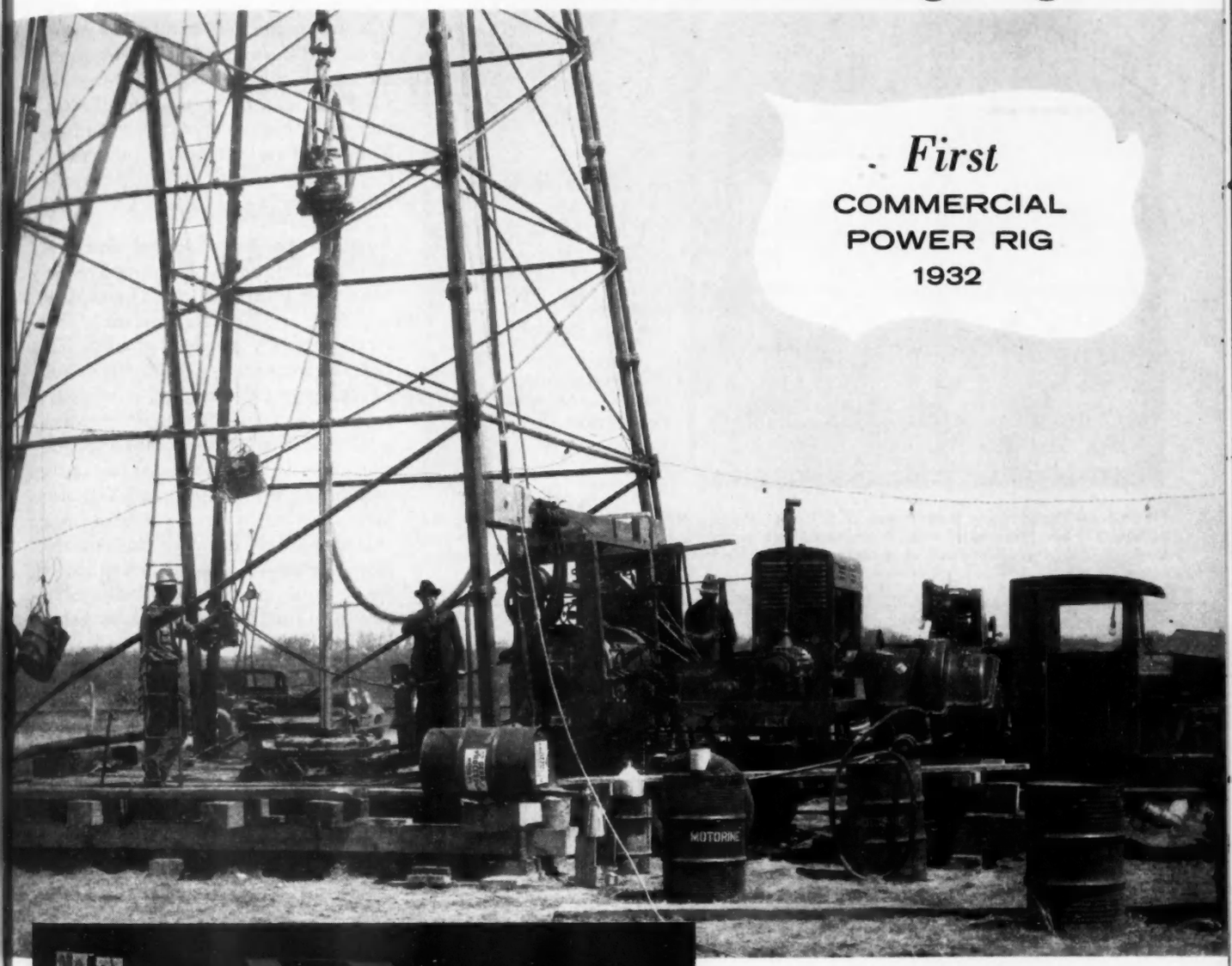

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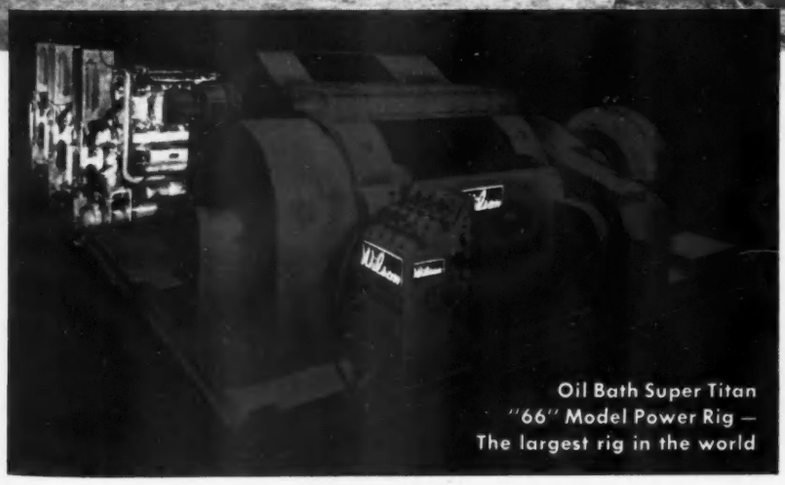

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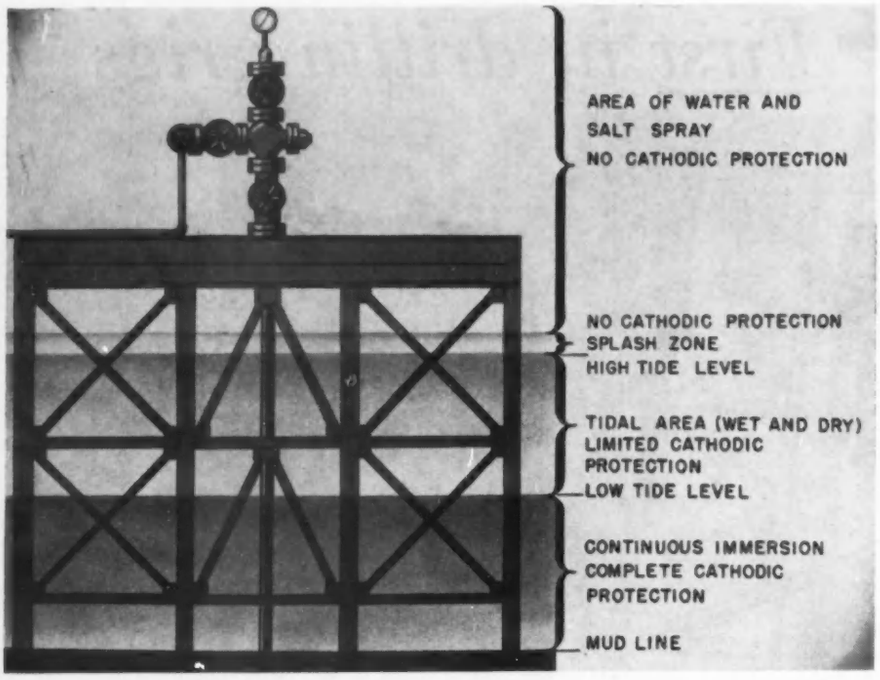

FIGURE 1—This drawing shows areas of a typical offshore structure which can be protected cathodically and those which must be protected with a coating. Area between low and high tide levels, as well as splash and salt spray zones, must be protected with a coating to prevent corrosion.

Offshore corrosion costs cut by 'cold galvanizing'

Zinc coating, sprayed on and chemically cured, is reducing corrosion by establishing chemical and physical bond with parent metal

WHENEVER A STRUCTURE, vessel or piece of equipment is placed offshore, all surfaces must be protected with a coating that will withstand initial corrosion and keep subsequent maintenance costs at a minimum.

A variety of paints and coatings, as well as cathodic protection, have been used by companies with offshore operations. Because of the peculiar nature of the typical offshore structure, operating as it does with most of the structure either in or only slightly above the splash zone, initial protection and future maintenance become particularly serious problems. Cathodic protection can be employed to protect those surfaces that are continuously immersed (Figure 1). Above the mean low tide level, however, some kind of coating or surface protection must be used. Even below the mean low tide level, a coating is recommended as the first line of defense against corrosion, with cathodic protection being supplied as a reserve. After the initial expense of applying the basic coating, the cathodic protection operates at a much lower cost in both current and replacement of anodes.

Among the coatings currently available for protection of offshore structures and equipment is an inorganic silicate, highly filled with metallic zinc, that can be sprayed on the surface, then chemically "cured" to form a chemical and physical bond between the metal surface and the metallic zinc coating.

Applied to Bare Metal Surface. The coating can be applied either before or after erection. The coating, in effect, is a "cold galvanizing," but when properly applied, actually outlasts conventional galvanizing. Ordinarily, only a single coat is necessary to provide protection from corrosion in a typical offshore structure application. Key to the successful use of the coating is the proper and complete sand blasting, down to a bare metal surface, before applying the inorganic zinc coating (Figure 2). Applied by spray gun, the coating is allowed to dry for a minimum of one hour before curing.

A unique property of the coating is the relative ease with which it is "cured." It can be cured in either of two ways: by baking for an hour at 350° F., not considered practical for large surfaces or structures, or by application of a chemical curing solution that goes on by either spraying or brushing. The chemical application, of course, lends itself ideally to the very large and complex structures involved in offshore drilling operations.

Tight Chemical-Physical Bond. The coating, when properly applied and cured, is approximately 2½ mils in thickness and forms a chemical-physical bond so tight that it is almost impossible to determine the actual interface between the coating and the bare metal surface. After the chemical curing is completed, the surface is washed down with fresh water to remove soluble carbonates and phosphates formed in the reaction. It is practically impossible to separate the coating from the steel surface.

Properties of the cured coating include exceptional resistance to abrasion and an ability to withstand normal expansion and contraction and moderate bending of the metal. Exposure to salt water actually aids in curing the coating, and prolonged exposure to extreme weathering con-

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FIGURE 2—Caisson to be used in offshore installation is being sandblasted to bare metal before application of inorganic zinc coating.

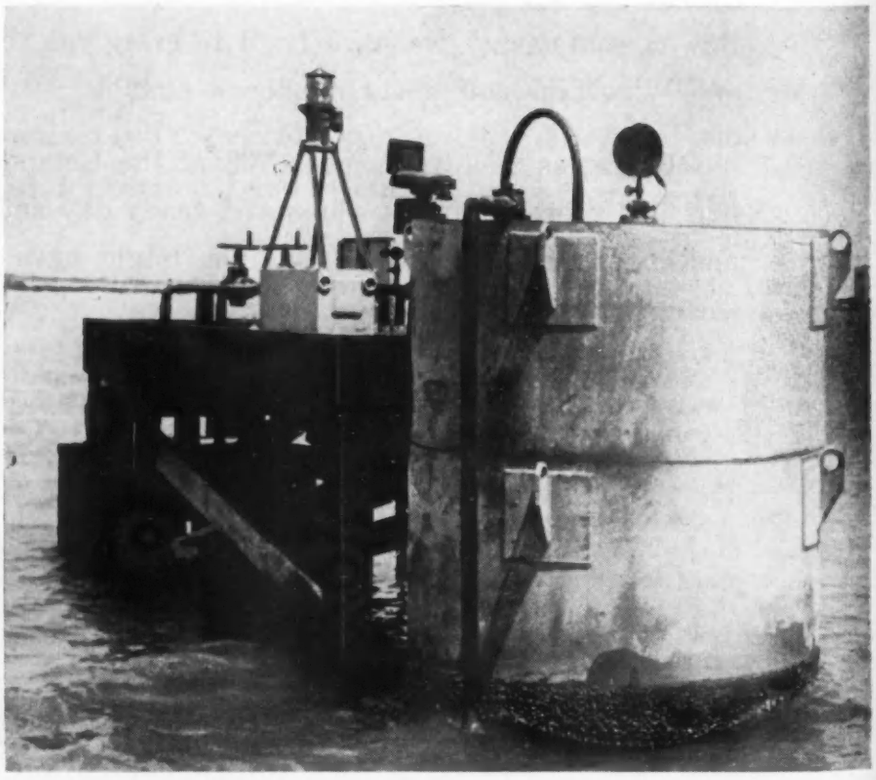
ditions, as for example in the Gulf area, has had little effect on the coating. An unusual property of the coating is its ability to provide its own cathodic protection should it be abraded or stratched off by accident. If it is abraded to bare steel, an electrochemical reaction between the zinc in the coating and the steel surface will be set up to cathodically prevent rusting. Whenever necessary, areas accidentally damaged or which have received unusual wear or abuse are easily repaired with a touch-up coat.

Early Coating Job 14 Years Old. The coating was developed originally in Australia. One of its first large scale applications in that country was a 21- to 30-inch above-ground pipe line, 223 miles long, which traverses salt flats, desert areas, fresh and salt water bodies, and in the 14 years since its installation in 1942, it has been subjected to extremes in humidity, temperature, exposure to brush fires, and sand blasting by desert dust storms. Protected originally with this inorganic zinc coating, the line still is in service and gives no indication of needing re-coating. Introduced into the U. S. in 1951, the coating has been applied to a number of installations where severe service is experienced, in a variety of fields, and it gives every indication of finding a growing number of uses in offshore drilling, production (Figure 3), and related phases of the oil industry.

Among the applications relating to offshore drilling was its use on the drilling platform "Mr. Gus," the first mobile rig designed for drilling in waters up to 100 feet in depth in the Gulf of Mexico. During construction of the platform in 1955, a single coating of the material was applied to the entire area above the wind and weather line, including the interior and exterior of stanchions, structural steel and the bottoms and sides of the upper platform.

Numerous other drilling structures in the Gulf Coast area have been

FIGURE 3—Caisson (below), which protects christmas tree of flowing well in Gulf of Mexico, was protected with inorganic zinc coating.



sure had been a problem. For the first time rigs, reserves and roughnecks were safe from the danger that had been considered an act of God. Operators were free to probe deeper for more pay.

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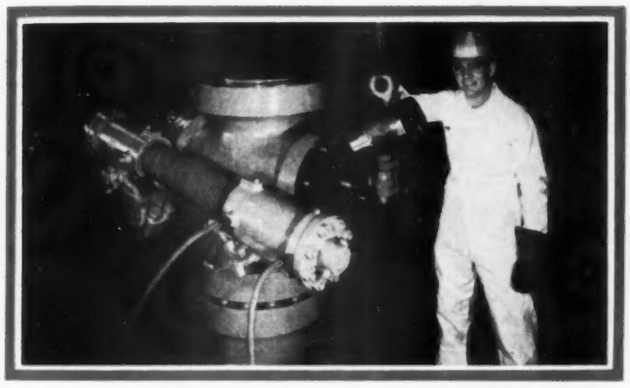

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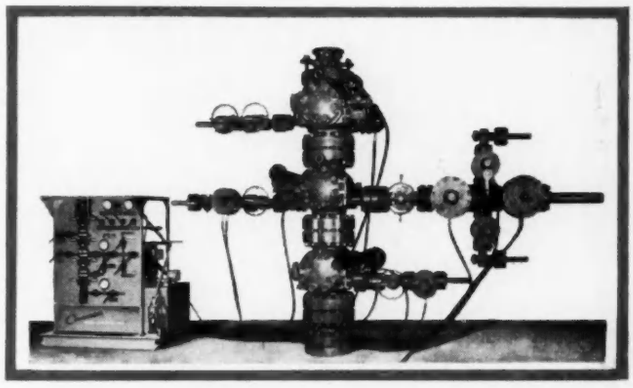

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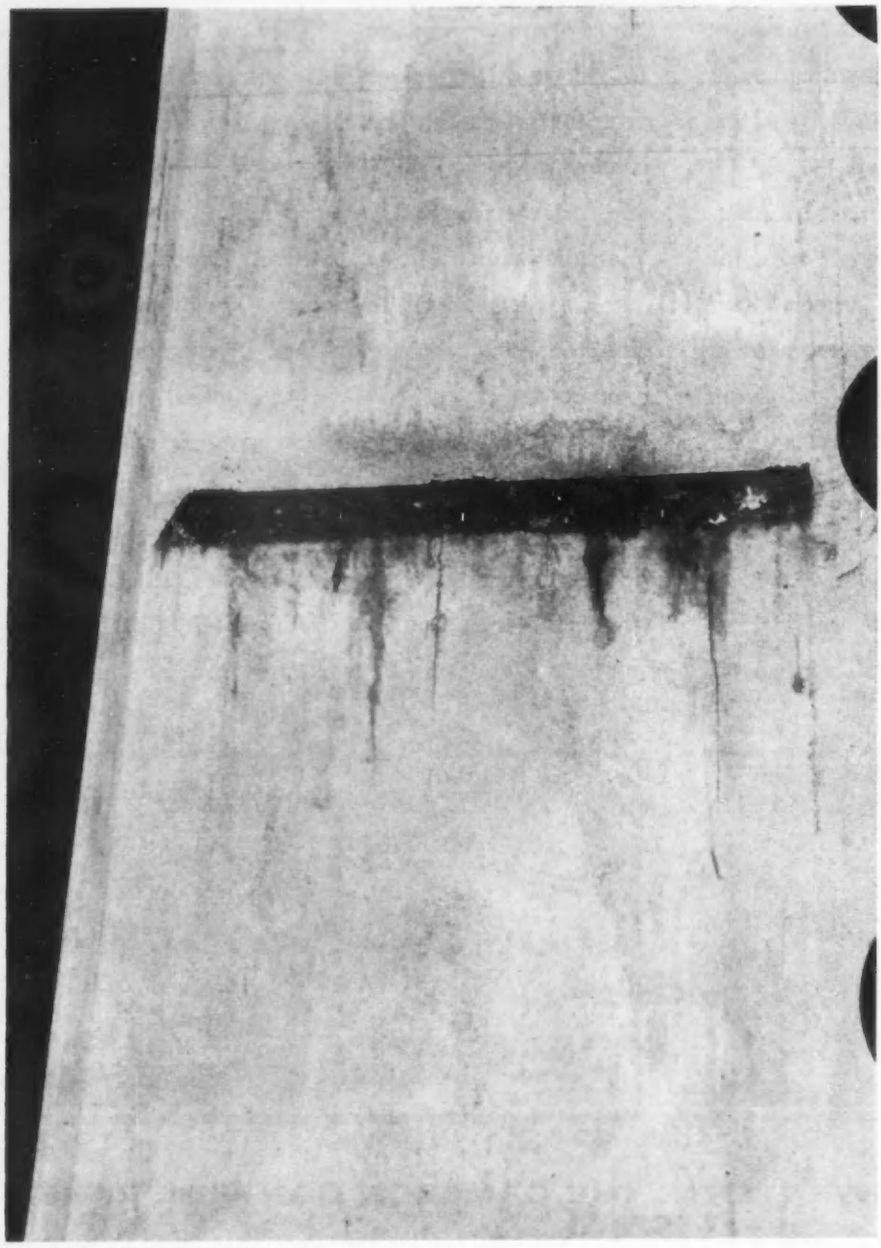

FIGURE 4—This photograph shows difference between a surface coated with inorganic zinc material and one that was not coated. During the coating of this cargo and ballast tank of a tanker, a spot-welded support for a painter's scaffold was not removed and remained in place for a year before it was finally taken down. The severely rusted area behind the bracket is in sharp contrast with the smooth, uncorroded area surrounding it that was protected with zinc coating.

similarly coated and service life so far indicates that the coating is providing excellent protection from corrosion.

A modified LSM operated by a major West Coast company, and which was designed to drill exploratory holes through the center of the hull in Pacific Coast waters, was protected by the inorganic zinc coating. Application was made on the entire hull area above the light load line, including the deck and center well.

Service Equipment Protected. Some idea as to the service life to be expected on offshore platforms and equipment can be gained from a study of applications that have been made on service barges whose hulls and deck surfaces receive salt spray, alternate wetting, and drying, and exposure to weathering comparable to that received by drilling structures.

In November, 1953, a work barge in the Corpus Christi area was protected with the zinc coating. Examined in mid-1956, the coating was found to be still in good condition and did not require re-coating. Another barge, coated in 1952, was inspected in September, 1956, and was found to be in excellent condition. The marine superintendent thought that his company would get another four years of service out of the coating and estimated they had realized a saving of about $5000 in these first four years by use of the zinc coating instead of conventional paints.

An oil well service company operating self-propelled barges in the Gulf area, following a series of tests involving test patches at various points along the hull and deck, coated its first barge in July, 1954. Except for some minor re-touching after a year or two of service, the protective coating is still in good condition. Based on these results, the company ordered five other barges coated during 1955 and 1956.

Coverage, as is the case with any coating or paint material, depends upon the roughness of the surface on which it is applied, but on reasonably smooth surfaces the zinc coating has a coverage of about 300 square feet per gallon and provides a film of adequate thickness.

The coating, as originally applied, is a reddish gray color but this soon changes to a stable, light gray matte finish.

Resistance by the inorganic zinc coating to severe corrosion, abrasion, and weathering has brought about further applications in the production, processing and refining fields. One operator in the Gulf area coated about 100 christmas trees in offshore installations, applying a single coat over base metal. After nearly three years, these are still in perfect condition and the company has ordered coating applied on all future completions. The coating operation is done in the shop before trees are sent out to the well.

Other applications of the zinc coating in coastal areas where salt air and corrosive conditions exist include storage tanks, cooling towers, exposed piping and production manifolds, caissons, crew boats, and gasoline plant and refinery equipment.

Costs involved in applying and curing the inorganic zinc coating compare favorably with multiple-coat applications of conventional materials.

Considering the long life indicated by installations thus far protected by the zinc coating, it seems apparent that the material already has gone far toward reducing the toll annually taken by corrosion in offshore operations. —**The End**

During an extensive tour of U.S. and Canadian oil industry centers in 1930, A. Beeby-Thompson (left) visited with the late E. L. Doheny, a U.S. oil pioneer, in the latter's Los Angeles offices.

A pioneering geologist recalls the early years

Long career of A. Beeby-Thompson is the chronicle of geology and oil field exploration itself

A. BEEBY-THOMPSON, at 85, has been an internationally known geologist for more than 60 years. His doughty career has led him from his London offices into almost every corner of the world —from the Baku oil fields of Russia to the salt domes of the Texas Gulf. The career of Beeby-Thompson is the chronicle of geology and oil field exploration itself . . . from the days when yellow fever, malaria and even the plague were no strangers in the geologist's tent and when transportation meant only horses, mules or camels.

Concurrently with his engineering training, he attended a science school where his studies included geology, physics, chemistry, and allied subjects, all of which proved of considerable help in his subsequent vocations. A few months spent (prior to departure for Russia) with a prominent firm of London consulting engineers engaged in parliamentary surveys was an invaluable adjunct to his experience in tropical Africa.

Articled for five years to an engineering firm upon his graduation from high school, Beeby-Thompson became a junior assistant in a water-well drilling and contracting firm in 1895. It was there he learned the technical aspects of drilling which led to his accepting a government post in West Africa to explore for ground water.

West Africa to Russia. Two years in West Africa, during which he contracted malarial fever which was to recur periodically for many years, were followed by an appointment in Russia's Baku fields until 1904. Marriage and the birth of two children, coupled with the initial signs of labor discontent and racial conflict in the oil fields, led him to return to London.

With a staunch belief in the future of the oil industry and finding Britain with few individuals experienced in practical oil field operations, Beeby-Thompson opened his consulting petroleum engineering offices. Soon, he was joined by a talented engineer who also had Baku oil-field experience, Campbell M. Hunter.

During the next few years, Beeby-Thompson's duties principally involved European assignments and periodic journeys to Peru and Trinidad. From 1908 until the outbreak of World War I in 1914, the consulting firm was deluged with requests for investigations of prospective oil areas throughout the world and for evaluation studies of productive properties up for sale or in need of development capital. This period marked the beginning of British financial interest in oil.

During 1904-1915, Beeby-Thompson accepted duties which required expeditions, sometimes hazardous, into many areas of Russia, Rumania, Poland, Italy, France, Spain, Portugal, Greece, Turkey, Cyprus, the United States (California, Wyoming, Oklahoma, Kansas, Texas), Canada (Alberta, British Columbia, Ontario), Mexico, Honduras, Cuba, Trinidad, Barbados, Jamaica, Peru, Venezuela, Colombia, Ecuador, British Guiana, Brazil, Argentina, Egypt, Sudan, South Africa, Madagascar, Angola, Ivory Coast, Burma, India, and the East Indies.

Army Service. Beeby-Thompson's oil career was interrupted temporarily from 1915 to 1918 by army service in Gallipoli, Macedonia and the Middle East.

The ten years following World War I represented a period of intensive worldwide oil field exploration due to an international scramble for foreign oil concessions. During this period, missions were undertaken to many parts of Africa, North and South America, the Caribbean, and to the Middle East, where prolific oilfields were disclosed in Iran, Iraq and Egypt. Although his duties necessitated long absences

abroad, he somehow contrived to write several books on oil field operations as practiced in those days.

It is well for those who operate in the United States and under favorable conditions abroad to hear the word, first hand, from a sturdy pioneer in geology who mounted his mule or camel and sallied forth when most who read this were not yet represented by a birth certificate.

Therefore, WORLD OIL is publishing the following account—Beeby-Thompson's own—of one of his assignments which reveals succinctly the obstacles which pioneering geologists had to meet and overcome to play their leading roles in oil's early days.

Here is Beeby-Thompson's story of troubles in Trinidad

By A. Beeby-Thompson

Pioneering in the West Indies under humid, tropical conditions where torrential, evenly-distributed rains nourished a rank growth of vegetation was a strange contrast with my oil field experience in arid parts of Russia and Peru. But convinced that Trinidad offered favorable prospects for exploration, as the result of knowledge gleaned from geological reports and from a casual visit in 1904, I induced a few responsible city magnates to finance an investigation of the island.

They were actuated by a patriotic desire to develop oil resources within the British Empire, and reports on the failure of previous attempts to discover payable oil in Trinidad did not dissuade them. When it was found that both the Colonial Office and the Admiralty supported the idea, events moved quickly. I was commissioned immediately to undertake the task of prospecting and, if satisfied, to seek rights for exploring Crown land and such privately held land as seemed desirable.

Armed with credentials and powers to negotiate, I reached Trinidad in January, 1906. Island officials, notified of my mission, extended a hearty welcome and promised full assistance. The services of John Cadman, Inspector of Mines, and Cunningham Craig, Government Geologist, were generously placed at my disposal for conducting a reconnaissance survey of districts known to exhibit indications of oil or promising structures for its concentration. Meanwhile, most of the inhabitants viewed this renewed interest with amused skepticism and took small notice of the mission.

Full speed ahead. Little time was spent in preliminaries. Burdened with a minimum of equipment, we proceeded to the famous Pitch Lake, from whence we extended our exploration into the thick jungle that covered much of the southern part of the island where oil indications were widespread and pronounced.

Every excursion into virgin forest was an adventure, for hunters' trails were few and passage had to be hacked with machetes through a tangled mass of undergrowth full of stinging or prickly plants harboring a host of venomous insects. Mosquitoes, hornets, ants, chiggers, ticks, and bête rouge (a sort of harvest bug) were greater nuisances than were the vipers, adders and pythons that also infested the undergrowth.

Exposed to daily deluges of rain when floundering along already flooded ground, swamps or waterways and frequently sleeping in hammocks slung from trees, it was no surprise that we should suffer from malaria and other tropical diseases. Loss of vitality due to fever, however, did not lessen our interest, although all of us eventually were put under medical care for a time.

Indications of oil were so common along certain strips of country that it was possible to follow the course of some flexures by their presence for long distances. They took the form of both active and dead mud volcanoes, issues of gas, seepages of fresh oil, deposits of asphalt, and outcrops of oil sand on scarps.

Several months of strenuous field work enabled me to determine where prospects appeared most promising. Fortunately, the terrain I favored most lay within easy reach of the Gulf of Paria and near a headland well suited for the healthy location of staff bungalows.

This combination of advantages existed at Point Fortin, near Guapo, within easy reach of the Crown Lands I sought to obtain for prospecting.

Temporary setback. However, on presenting a petition to the authorities, I was disappointed to learn that part of the Crown Lands I sought lay within three miles of the Pitch Lake and was leased to others for asphalt development. I also heard that a license had already been promised to Lord Dundonald covering part of the land selected.

Outside these areas, I selected—and was promised—a prospecting license. Negotiations with the owners of La Fortune and Adventure estates were such as to insure their acquisition on acceptable terms.

Returning to London, my recommendations were approved by the board. Friendly negotiations with Lord Dundonald led, with the consent of the Colonial Office, to a merger of interests. A part owner of La Fortune estate, who came to London, approved conditions proposed for its acquisition. Thus, negotiations were sufficiently advanced in November, 1906, to authorize purchase of a drilling rig and other equipment and to engage a staff.

I returned that month to Trinidad, and bought a mile of old Decauville track from a Cedros estate. It was laid

TRINIDAD TODAY

In the approximately 50 years of Trinidad's oil history, the island's crude oil production has reached an annual level of more than 90,000 barrels per day. And latest available figures reflect an upturn in almost every phase of oil field operations.

In 1957 crude oil output totaled 34,063,287 barrels, an increase of 18.1 percent from the previous year. Also in 1957, the number of wells completed increased by 19.8 percent to 314 from the previous years (WORLD OIL, International Outlook Issue, Aug. 15, 1958, Page 152). Of the 314 wells completed in 1957, 89.8 percent were successful. The average number of drilling rigs in operation amounted to 29 in 1957, and total footage drilled rose to more than 1.3 million feet.

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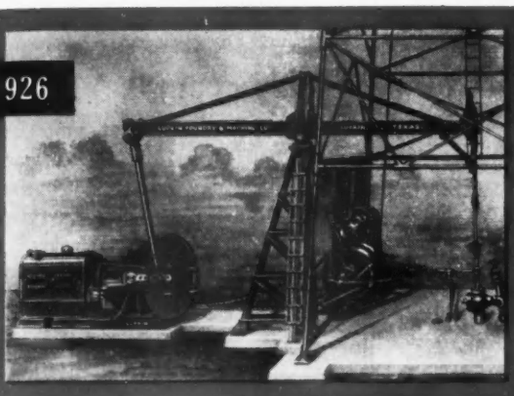

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inland from the coast to facilitate plant transport. A number of shafts were sunk to disclose structural features that would guide the selection of sites for initial drilling.

Between visits to the field, I spent considerable time in Port-of-Spain discussing with the various state departments questions which were regarded then as the normal functions and responsibilities of a consulting engineer. They included such matters as rights-of-way for roads; pipe lines; electric and telephone cables; clearing forests; felling and use of timber; navigation; taxation; customs duties on imported equipment; excise taxes; amount and form of royalty; drilling obligations.

But just as our efforts were shaping up, a serious situation developed on the field, due to malaria and nightly attacks by vampire bats which sucked blood from unprotected sleepers. With almost all of the staff incapacitated by these attacks, a serious outbreak of yellow fever accentuated our fears after a number of deaths.

In January (1907) I screened all dwellings, as was done in Panama, and was given the assistance of a Government medical officer to trace the breeding places of mosquitoes and take measures for their eradication. The draining of stagnant water pools and the spraying with oil any water that could not be drained and the enforcement of sanitation led eventually to a marked improvement.

Equipment arrives. By January's end, most of our equipment had been landed. Immediately afterward, an experienced oilfield manager and a qualified U.S. cable tool driller arrived. Drilling was begun in May, but at a depth of 150 feet technical difficulties caused us to move to a second location. In September, additional equipment was ordered and a second driller was engaged to speed up operations.

Although better drilling rates resulted and cavitation from heaving formations was to some extent checked, a new, rare and unexpected trouble arose which caused abandonment of the hole at 381 feet and the selection of a site for the third hole. The new obstacle was the extruding sticky semi-fluid asphalt which prevented free movement of the percussion drilling tools.

Fewer drilling difficulties were encountered in Well 3, which was located north of Well 2 where formations dipped at a low angle. After drilling through several oil sands, we found flowing oil at 700 feet. This was the first of a succession of producing wells that assisted the raising of funds for increased development work.

I spent the first three months of 1909 in London in discussions with Colonial Office officials and the Admiralty during the drafting of a lease. It was in April that I returned to Trinidad to complete agreements with the estate owners and to settle plans for expanded development.

Provision was being made for additional capital in the projected new company, and estimates had been prepared for a field expenditure sufficient to furnish 10 drilling rigs with which to complete 20-30 wells a year.

Stock sale a success. Pressed by London for notice that all local affairs had been settled so stock in the new company could be sold, it was not until May 14 that I could reply in the affirmative.

Flotation of Trinidad Oilfields Limited in February, 1910, was a huge success. It was oversubscribed on the day of issue, therefore, immediate steps were taken to expand the proposed program of development.

By this time, Well 4 was flowing intermittently from 767 feet at a rate of about 50 barrels a day, and Well 5 was producing natural gas at shallow depth. On June 1, it came in as a gusher.

Much of 1910-11 was devoted to construction of dwellings, offices, workshops, stores, storage tanks, installation of electric light, water plant and telephones, and the clearing of jungle for roads and well sites. A small refinery was erected, and shipping facilities improved.

Once this work had been accomplished, drilling proceeded more smoothly, with each well proving a commercial producer.

However, this heavy initial production was followed by sanding up as was the case in the Russian and Borneo oilfields. Well 13 flowed 25,000 barrels in 3½ hours. The sanding problem was nothing new, and I was convinced it would be solved in time by devices which were being developed in other countries, such as screens, gravel packing, production chokes, etc.

Far from satisfied with the rate of progress in Trinidad, the Board requested that I visit the field in September of 1912. Realizing that some incentive was necessary to instill life into the drilling crews, a drilling contract was negotiated and put into force November 1 under which all drillers derived substantial benefit.

Afterward, wells were drilled at such a rapid pace that it became difficult to sustain the flow of casing and other supplies. Experiments with the rotary method were proving very encouraging, and a drilling rate of 60 feet a day had been attained with the primitive equipment then available.

More capital sought. Returning to England, I learned that negotiations were under way to obtain more capital. It was felt by some of the directors that only by alliance with a powerful oil group could development proceed on the scale warranted by prospects.

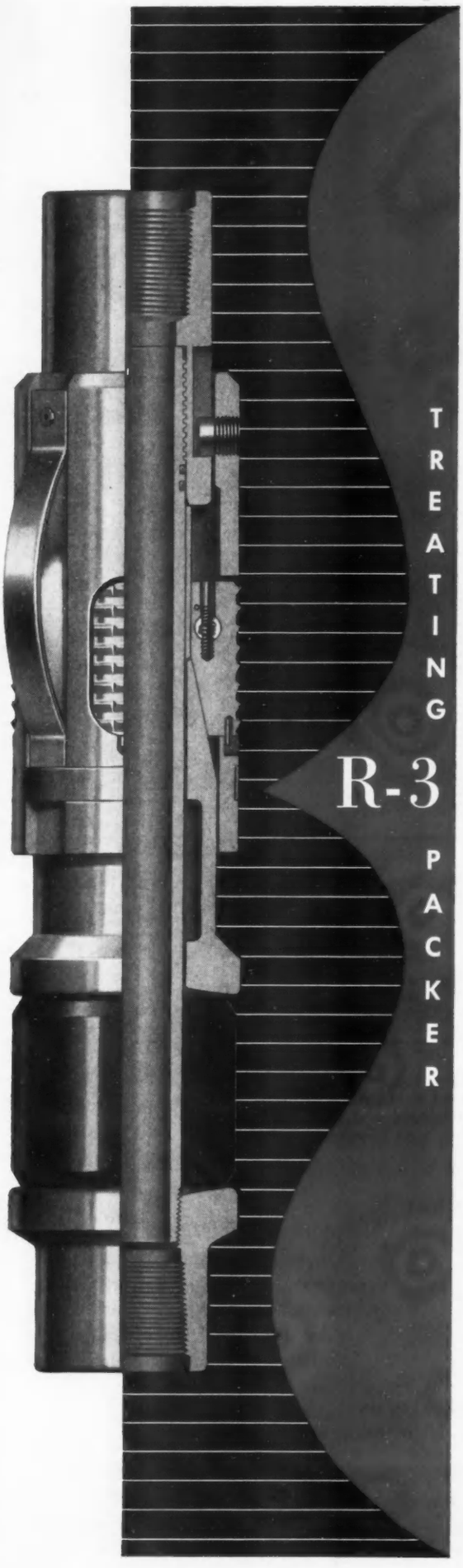
In February, 1913, the Shell Group became sufficiently interested in the project to send a geological party to Trinidad. Developments quickened and by the end of March the terms for taking over TOF by Shell were virtually agreed upon. Shareholders were notified of these intentions on April 3.

Meanwhile, events moved swiftly with more frequent well completions. Sales were about meeting field expenditures. On March 25, Well 22 came in with an initial flow of 10,000 barrels daily at 1,400 feet. On April 29, Well 33 began producing from 980 feet at a rate of 6,000 barrels daily. Of greater importance, however, was the discovery of a powerful gusher on May 5 on Parry Lands at only 450 feet.

By arrangement with Shell, I continued to direct operations until they could be taken over later in the year after exercising their option.

Although some years passed before techniques and equipment were designed to combat such technical difficulties as heaving formations and eruptions of sand, the Fortin-Guapo field responded well to these new techniques as operations expanded.

The original concession has proved to be one of the best oil producers in Trinidad, and, after many years, still is producing freely. In 1954, the Point Fortin field produced 3,317,800 barrels of oil, or approximately 9,100 barrels per day, which was tantamount to almost 14 percent of the island's output after 40 years of active development.



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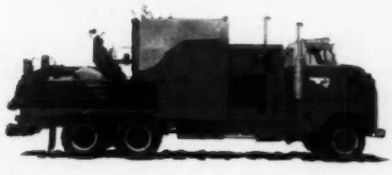


Franco Delhi exploration is under way in Algeria

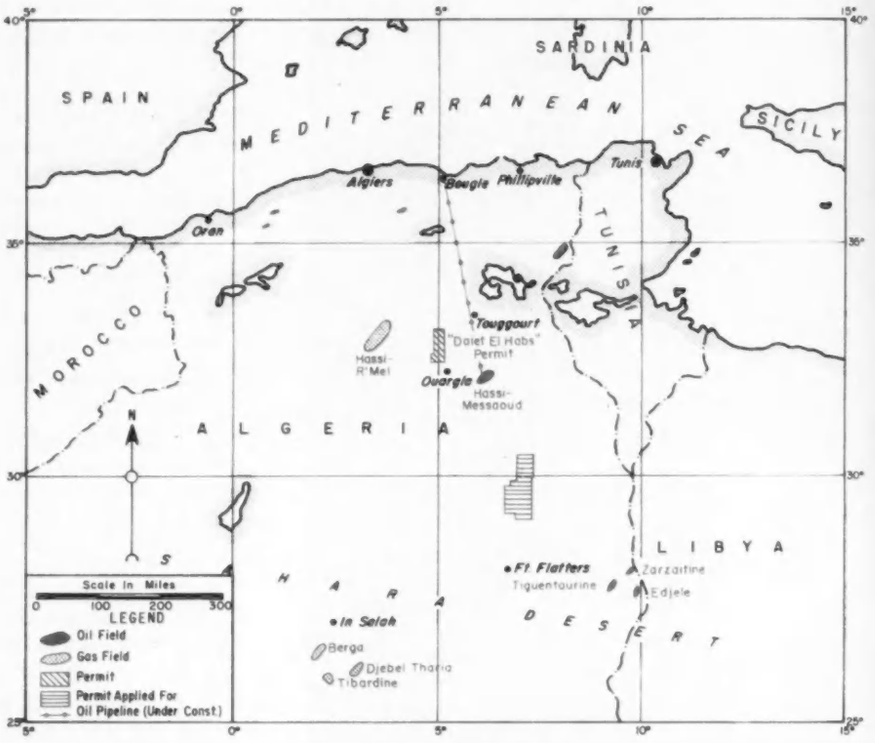
Franco Delhi, S. A. and associates are doing photogeological work on their 445,000 acre Daiet el Habs exploration permit area in the Sahara Desert of Algeria, French North Africa. That preliminary work will be followed by a geophysical examination.

The permit area lies 75 miles east of Hassi R'Mel gas field and 80 miles west and a little north of Hassi Messaoud oil field. Hassi R'Mel is a major condensate bearing gas field with gas reserves reported in excess of 11 trillion cubic feet. Hassi Messaoud produces 43 degree API gravity oil, and has proved reserves estimated in excess of 2 billion barrels.

Franco Delhi and associates have applied for another permit of 1.8 million acres. That land lies on trend between the Hassi Messaoud field and the Edjele, Zarzaitine, and Tiguentourne producing areas to the southeast. Those fields are adjacent to the Libyan border. The group plans to apply for additional exploration permits in the Sahara region as they become available.

Franco Delhi, S. A. is a wholly owned French subsidiary of Canadian Delhi Oil Ltd. Franco Delhi is the operator for the associated French, Canadian and American entities. Participating interests are divided as follows: Franco Delhi 30 percent; Petropar (owned by the French government) 35 percent; Francarep (sponsored by the French banking firm of Worms & Rothschild) 16 percent; E. Constantin, Jr., U. S. refiner, 6 percent; Allen & Company, a U. S. investment banking firm, 7 percent; Vaughn Brothers' Trusts 3 percent; and Home Oil Company Limited 3 percent.

Franco Delhi has established main offices in Paris, France. It is organizing operational headquarters in the city of Algiers, Algeria.



Franco Delhi and associates are doing exploration work on a permit area between Hassi R'Mel and Hassi Messaoud fields, Algeria. They also have applied for an exploration permit between Hassi Messaoud and Edjele fields.

Two big inch pipe lines will move Algerian oils

Bechtel Corporation was expected to sign a contract with Trapsa, new French pipe line entity, to build a 475-mile pipe line from the Edjele-Zarzaitine-Tiguentourine crude producing area in extreme eastern Algeria to Gabes in Tunisia.

Capacity of the line, expected to be completed in 1960, will be about 100,000 barrels daily.

The fifth and sixth wells in Zarzaitine field, near Edjele, have been undergoing production tests.

Construction of another big-inch crude line in Algeria, from Hassi Messaoud field to Bougie, has been reported under way. Some of the 24-inch pipe for the line had arrived at the railhead at Touggourt late in 1958. But pipe laying had not commenced at that time.

Production from Hassi Messaoud started at the beginning of 1958. By pipe line, rail, and ship, the oil has been reaching French refineries. Seventeen wells have been completed in the field, including 16 oil producers.

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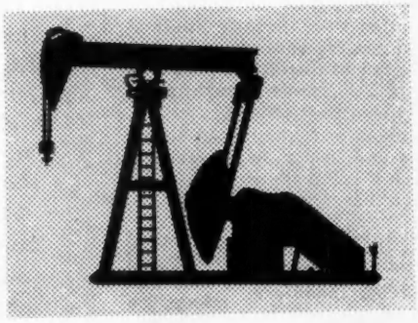
. . . . . to all men (like our own "Mike Le Grand") with oil in their blood.
We salute also the explorers, the drillers and the producers who slake the thirst of an oil conscious world.



This puppet scene, from the film "Prospecting for Petroleum" made for Shell Oil Company, shows GEORGE BISSELL, the man behind the first oil well, congratulating COLONEL DRAKE, who drilled it. He struck oil at 89 feet in Pennsylvania in 1859.

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1953 INTERNATIONAL PETROLEUM EXPOSITION—This aerial view shows some of the 1,484 oil industry exhibits which attracted more than 400,000 visitors. At the 1959 show, officials expect one-half million visitors and more than 2,000 exhibitors—including several hundred exploration, drilling and production exhibits.

IPE at Tulsa to feature oil industry progress

More than 2,000 companies will display half-billion dollars' worth of equipment

ADVANCE COMMITMENTS indicate that the 14th International Petroleum Exposition at Tulsa, May 14-23, will put on display the largest and most varied assortment of exploration, drilling and production equipment in the show's 36-year history.

More than 98 percent of the available display space already has been contracted. With additional acreage added this year, more exhibitors have signed up to date than actually exhibited in any previous show.

IPE President W. K. Warren reports, "We expect at least 30,000 oil men from every phase of the oil industry to be on hand. They will have a chance to look at equipment worth more than one-half billion dollars. Exhibits will range from exploration to petrochemicals—in fact, everything connected with oil, during the ten-day run of the show. We expect more than 2,000 individual companies to exhibit their products."

International aspect stressed. "We have long called the exposition an international show, but next year will see the scope widened to larger proportions than ever," Warren said. "While our show has been devoted primarily to domestic exhibits in the past, this time we will have at least 12 exhibitors from overseas and more are now negotiating for space." At the last exposition visitors came from 36 states and 51 countries.

The "showcase of the industry" promises to be one of the top attractions in commemorating the centennial of oil. The dates have been set in conjunction with the Fifth World Petroleum Congress in New York to facilitate international attendance. Special tours for delegates to the Congress have been arranged to include

the oil show and also several field trips in the Kansas-Oklahoma-Texas area.

Industry progress on display. One of the major highlights of the show, as in previous years, will be the Hall of Science. Scientific exhibits of all major advances in exploration, drilling and production techniques since 1953 will be shown, as well as new developments in other phases of the industry. The science exhibit is one of the most popular spots at the exposition since most of the displays are moving models and are explained in laymen's terms.

Another of the institutions at the oil show will be the salute to "old timers." More than 740 industry pioneers were registered at the 1953 show, and they will again be feted with special recognition and awards. "Old timers" in the fields of production, refining, pipelining, natural gas and supplies, and equipment will be chosen for special honors.

A "Pioneer of Pioneers" or Grand Old Man of the Industry will be named in recognition of his outstanding contributions to the progress of the industry. Old Timer awards were originated in 1927 by John D. Rockefeller, Sr.

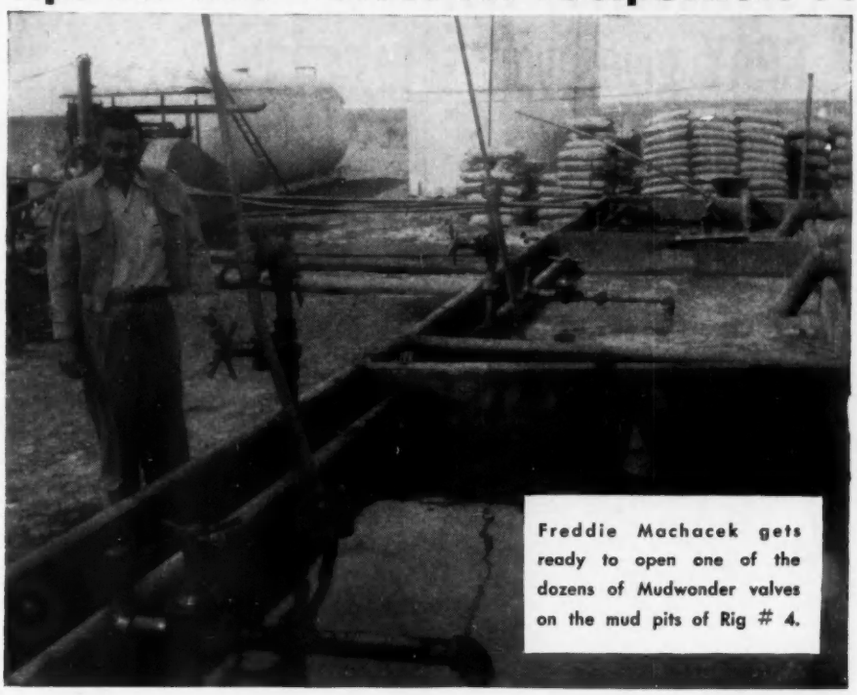
Members of the National Oil-Equipment Manufacturers and Delegates Society, better known as Nomads, have set committees for entertaining and otherwise taking care of visitors from other countries. According to President Warren, "Our ambassadors have been the busiest group we've had. They have personally invited the chiefs of state from 51 countries and individual oil men from all over the world."

Housing arrangements. The IPE Housing Bureau has been formed to take care of the thousands of visitors to Tulsa. To supplement hotel space, residents of the city make their homes available to provide reasonable-priced, comfortable housing. Cabled requests for housing should be directed to "OILSHOW, TULSA." The mailing address of the housing bureau is 214 Oil Capital Building, Tulsa, Okla.

Warren sums up the advance arrangements for the show in these words, "The early contracts and world-wide interest displayed this far ahead of opening day assure that the 1959 exposition will be the biggest and best of what is already the largest single industry trade-fair in the world."

—The End

Tips on Mud Valves for Toolpushers . .



Freddie Machacek gets ready to open one of the dozens of Mudwonder valves on the mud pits of Rig # 4.

MUDWONDER Ideal for Versatile Service

by Freddie Machacek, Toolpusher, Rig #4
B.B.M. Drilling Company, Midland, Texas

ABOUT two years ago I put a *Mudwonder* valve on our fill-up line just to see how it would make out. I soon found that *Mudwonder* worked fast and easily, without binding, even while bleeding off the line at 1600 lbs pressure. It did so well I tried more *Mudwonders* on the tough job of mud pit service—and they were so successful I've standardized on *Mudwonder* ever since!

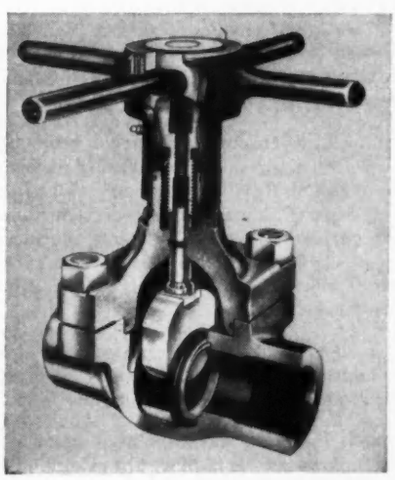
Valves on mud guns and jets take a terrific beating, but we've had very little trouble with *Mudwonders.* As a matter of fact, our first ones are still in service; we replaced the stem packing on one valve—that's all! Because replacement parts are so easy to identify, we never have any trouble getting the exact part we need. In fact, the valves are designed to use the same seat and gate for both pressure classes.

When we have to dress a *Mudwonder,* the job can be done without disturbing any connections. The valve is out of service only about 10 minutes, start to finish, regardless of size. Another thing—they never sand up. Bob Lawrence, Edward *Mudwonder* Representative, says this is because the design causes the mud to flush the bonnet automatically.

Mudwonder valves are available in 2", 3" and 4" sizes; with screwed or flanged ends; rated at 2000 psi WP (4000 psi test) and 3000 psi WP (6000 psi test). See your favorite oil field supply store for complete information, or write Edward Valves, Inc., East Chicago, Indiana, subsidiary of Rockwell Manufacturing Company.

(Adv.)

Mudwonder cut-away view shows the one-piece seat insert, with Buna-N molded integrally over steel wear rings; chromed gate with "T" slot connection; separated stainless stem and double thread construction.



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Hines H. Baker

Michael L. Haider

Hines H. Baker, who relinquished his presidency of **Humble Oil & Refining Company,** Houston, in April, 1957, to become director and member of the executive committee of Humble's parent firm, the **Standard Oil Company of New Jersey,** has left that post, effective January 1, 1959. Baker began his oil industry career in 1919. He had become a director by 1937, was elected a vice president in 1945 and the president in 1948. The Standard Oil Co. has announced that Baker will be succeeded on the board by **Michael L. Haider,** president of the affiliated International Petroleum Company.

Alan C. Roberts has been appointed manager of the newly created Oil and Gas Section of the **Fort Worth National Bank's Trust Department.** Roberts, who has been with **Cities Service Oil Company of Delaware** since 1951, has served the past two years in Fort Worth as Special Representative for property acquisition in that Company's Land Department. Prior to coming to Fort Worth he was Cities Service's Manager of Crude Oil Purchases and Sales in Midland, Texas.

Alan C. Roberts

Houston Natural Gas Production Company has appointed **Fred M. Thompson, Jr.,** as Corpus Christi, Texas, district geologist.

Wilbur B. Sherman, well known geologist, was elected president of **Pan American Land & Oil Royalty Company of Dallas.** In the past, Sherman has been associated with the Superior Oil Company, Standard Oil of California and a former vice president and director of DeGolyer and MacNaughton, Inc.

R. E. Griswold has been appointed staff geologist of **The Texas Company's** Domestic Producing department at New York.

Francis E. Heath was appointed agent and chief geologist for **Sun Oil Company's** Southwest Production division.

Paul W. Sheldon, formerly a supervisor in the public relations department of Young & Rubicam, Inc., New York, has joined **Gulf Oil Corporation's** public relations department. He will be located in Gulf's new office in Canada House, New York, and will report directly to Craig Thompson, the company's director of public relations.

Raimundo J. Galletti, chief of the **Argentine Government Oil Fields Commission** in New York, N. Y., has been transferred to an executive position in the home office of **Yacimientos Petroliferos Fiscales (YPF) in Buenos Aires.** He was to be replaced in his former post by **Gregorio A. Cariglino.**

Raymond M. Thompson, contrary to previous announcements, did not accept the position of vice president in charge of exploration for the **Halbouty Alaska Oil Company.** Due to commitments in consulting geology, he remains as president of **Global Exploration Company** in Denver. The firm continues to specialize in surface and photogeology and oil evaluation work on a consulting basis.

William Pendleton, formerly in the Southwestern division office of **The Pure Oil Co.** at Tulsa, is now located at that firm's Bismarck, N. D., office.

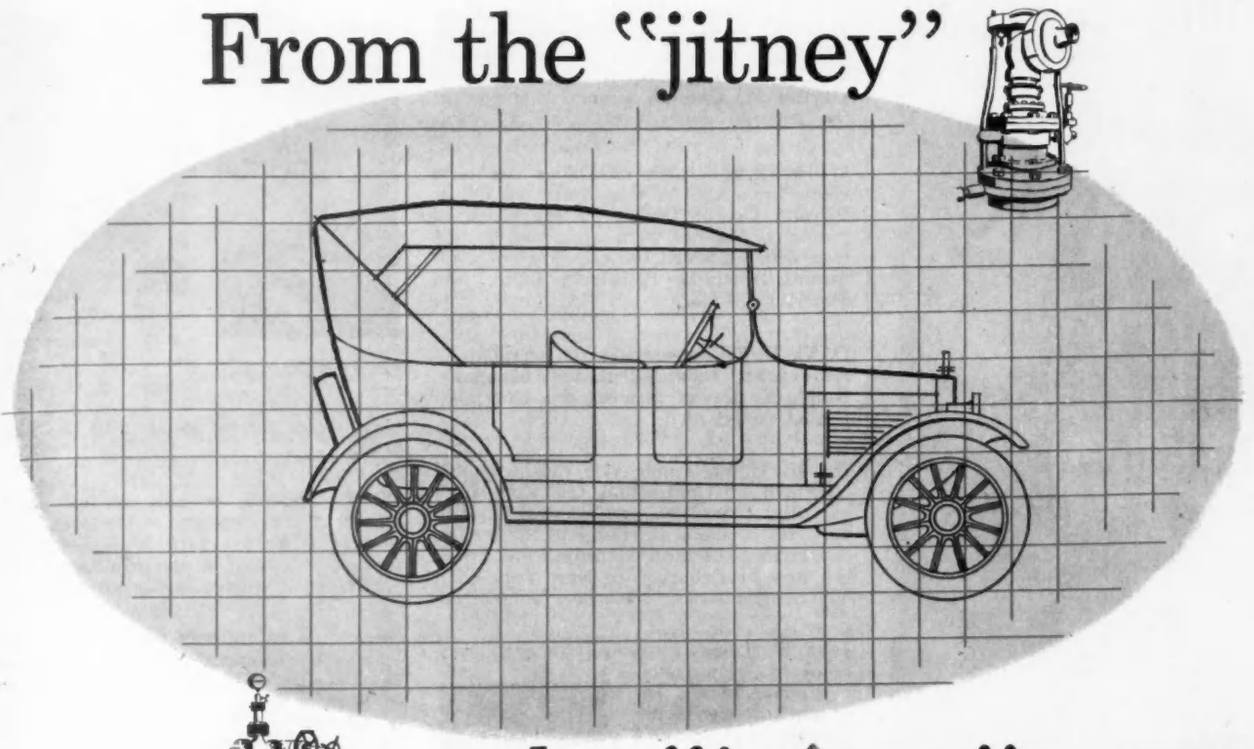
The Carter Oil Co., has announced the transfer of **Robert (Bob) Pitcher,** scout and landman, from Ponca City, Okla., to Vinita.

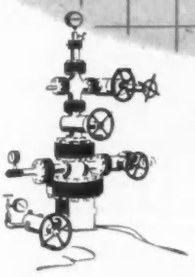
Jake L. Hamon, independent oil operator of Dallas, was honored recently as the first recipient of the **Carl A. Young Memorial Award** presented by the **Division of Production of the American Petroleum Institute.** The award was given to Hamon at the thirty-eighth annual API meeting held in Chicago.

Jake L. Hamon

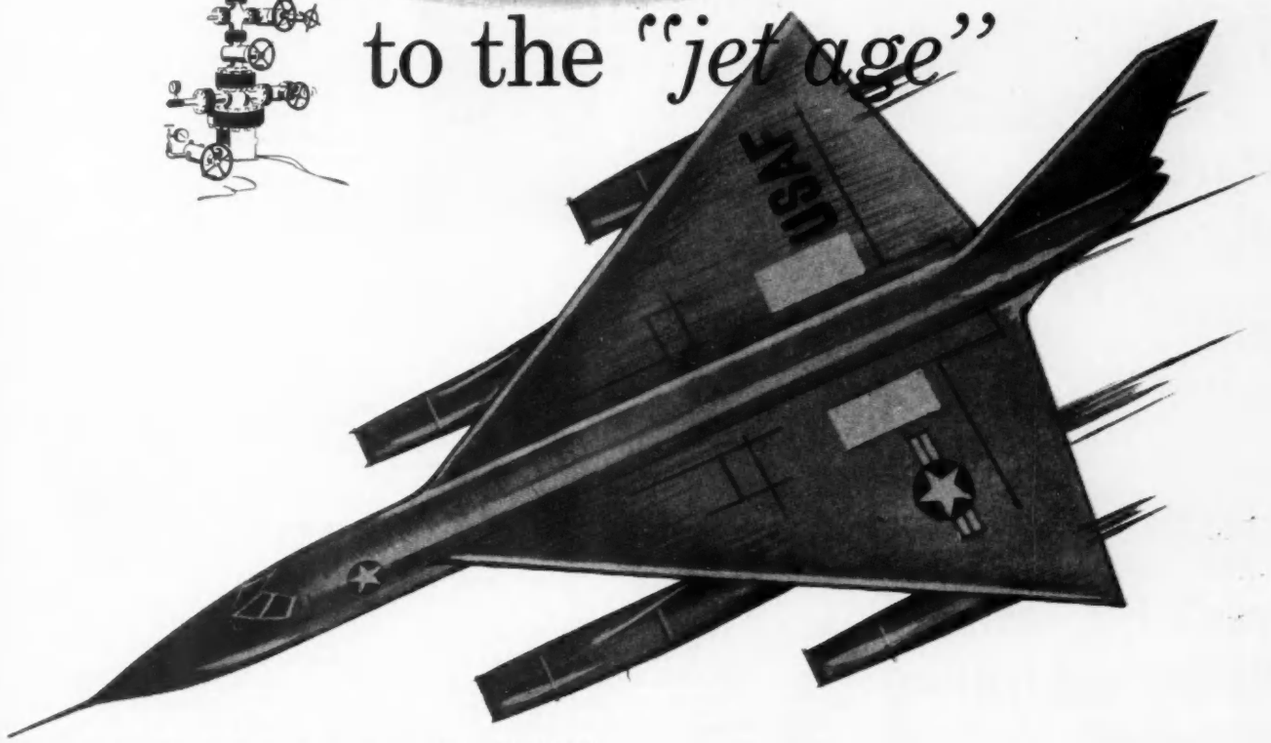
Socony Mobil Oil Company, Inc., recently announced the appointment to new positions of three research department executives of that company, as part of a new organization plan for its research activity. Under the new program the research department will consist of four functional divisions: Applied Research and Development under **Guy R. M. del**

From the "jitney"





to the "*jet age*"



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Wilbur B. Sherman of Dallas has been elected president of **Pan American Oil & Royalty Co.** of Dallas, by the board of directors. He has been associated in the past with Standard Oil Company of California, Amerada Petroleum Corp. and Superior Oil Co.

D. C. Dunaway was elected president of **American Independent Oil Company. Ralph K. Davies** assumes the chairmanship of the board.

Ira H. Cram, senior vice president and chairman of **Continental Oil Company's** executive committee, and **Howard H. Hinson,** vice president in charge of the foreign department, both of Houston, will establish new headquarters in New York City, effective January 1, it has been announced.

John M. King, Chicago oil company president, has been named a director of the **Independent Petroleum Association of America,** oil industry organization representing the independent producer and private investor. King is president of King-Stevenson Corporation, an oil production and operating company; a partner in King-Stevenson Oil Company, oil and gas exploration and development firm; and president of Tioga Petroleum Corporation, oil and gas production purchasing and development financing corporation.

John M. King

Jerry Luboviski has been appointed Director of Public Relations and Advertising for **Union Oil Company of California.** Before joining Union Oil he had been associated with Southern California newspapers and more recently been Manager of Public Relations for the **Western Oil and Gas Association.**

Dr. Marland P. Billings, Harvard University, was recently elected as new president of the **Geological Society of America** for 1959. **Dr. Hollis D. Hedberg,** Oakmont, Penn., exploration coordinator for Gulf Oil Corp., was elected new vice president of the group.

Andre Masson, district geologist, **Skelly Oil Co.,** was recently elected president of the **North Dakota Geological Society** for 1959. He succeeds **Don Saber** of **Sinclair Oil and Gas Company.**

Lloyd N. Unsell, director of information for the **Independent Petroleum Association of America,** has been transferred to Tulsa after several months' assignment in Washington, D. C. **Richard Lambert** will continue as a member of the IPAA public information staff at the association's capital office.

Richard E. Nelson, Jr., has been named president of **Amoco Trading Corporation** which is a newly organized subsidiary of **Standard Oil Company (Indiana).** The new company will buy, sell, trade and transport crude oil and petroleum on an international scale. Nelson has been director of operations in Standard's Supply and Transportation Department, Chicago. Offices of the newly organized company will be in New York City. Other offices abroad will be opened later.

R. E. Nelson, Jr.

W. R. Thixton, recently retired as vice president and manager of the **Tulsa Division of Sinclair Oil & Gas Co.,** has opened an office in the **Midstates Building.** He will engage in consulting work.

Sunray Mid-Continent Oil Co., has established a permanent office in Anchorage, Alaska, to handle the company's growing interests in the new state. It has also been announced that **Dick Eckert,** of the California district office, will head the new Alaska office.

Richard Harding, geologist at Bismarck, N. D., for **The Texas Company,** has been transferred to the New Orleans, La., office.

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CORPUS CHRISTI, TEXAS—Tolle, Inc. ..... TE 5-5367
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Horne Well Service Co. 3-5396
HOUMA, LOUISIANA—Camco, Inc. 7330
HOUSTON, TEXAS
Assoc. Eng. & Eqpt., Inc. ..... CA 5-1103
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Rainbo Service Co. ..... ME 4-2131, ME 4-0105
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Regan Forge & Eng. Co. ..... TE 2-5395
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VICTORIA, TEXAS—Camco, Inc. ..... HI 3-9521
WHITTIER, CALIFORNIA
Kline Wire Line Co. ..... OX 3-2731
WICHITA FALLS, TEXAS
Hudson-Eads, Inc. 322-8584, 322-1792, 767-8727, 723-4690, 767-3793

Robert C. Hadden Walter I. Weed, Jr.

Three executive promotions have been announced by **Tidewater Oil Company. Irving E. Chapman** was named executive assistant to **John E. Roth,** senior vice president and director. **Robert Hadden** was named executive assistant to **Charles R. Brown,** western division vice president and general manager. **Walter I. Weed, Jr.,** was named supervisor of the western division oil purchase and exchange department. He will manage oil purchase and related supply activities for Tidewater in the seven western states and Hawaii. Hadden succeeded to the post formerly held by Chapman, while Weed was advanced to the position previously occupied by Hadden.

Irving E. Chapman

Georges Vorbe, chief research geologist in Dallas for **D. D. Feldman Oil and Gas** since his return from a two-year assignment in Cuba, has been transferred to Paris, France, as geological counsel to the Eastern Hemisphere Subsidiaries of the Feldman organization.

Anibal R. Martinez, recently district geologist with **Creole Petroleum Corporation** in Maracaibo, Venezuela, has joined the staff of **Jersey Production Research Company** at Tulsa, Okla.

Gene A. Smitherman has recently opened his office as a consulting petroleum engineer in the **Bank of the Southwest Building** in Houston. Evaluations of producing properties, property operations and well completions are among the many services Smitherman will perform.

J. J. Razor, division manager of the Tulsa office of **Wanda Petroleum Co.,** has been appointed vice president. He has been division chief of Wanda since January 1 of last year and present plans call for his office to remain in Tulsa.

Dr. Michael J. Rzasa has been appointed manager of research laboratories of **Cities Service Research and Development Co.** Previously manager of exploration and production research at Tulsa, Rzasa has managed the company's product development laboratory at Cranbury, N. J., since January 1957. He will supervise the laboratory in Tulsa, Cranbury and Lake Charles, La., from his New York headquarters.

Horace K. Quattlebaum, a senior engineer in the petroleum engineering section of **The Carter Oil Company,** has been promoted to be district engineer at Carmi, Ill., in the Tri-State field.

Earl Baldridge, president of **Champlin Oil and Refining Co.,** has been given a medal by the Republic of Panama in appreciation for the work the Enid and Fort Worth firm is giving the economy of the Central American country. The medal, designated National Order of Vasco Nunez de Balboa, is generally bestowed only to high government and military officials.

Grant Heatzig has recently joined the staff of **Harry Wassall & Associates, Consulting Geologists,** headquartered in the Sinclair Building in Havana. This organization maintains a branch office in Buenos Aires with representatives in most of Latin America and the Caribbean.

C. H. Stewart, exploration engineer at Great Bend, Kansas, for **Shell Oil Co.,** has been made reservoir engineer at Centralia, Ill. **W. E. McCool** is the new exploration engineer at Centralia.

Cities Service Oil Co. has consolidated its Michigan activities with its Illinois office at Olney, Ill. All personnel except **H. B. Wright,** district production foreman at Mount Pleasant, have been transferred to Olney.

G. C. (Jerry) Roberts, exploration manager of **Miami Petroleum Co.,** Abilene, Texas, has resigned to become a petroleum consultant.

Don E. Hollingshead, a geologist at Midland, Texas, has joined the Rocky Mountain area office of the **American Climax Petroleum Company.**

Charles B. Barry and **J. A. Richardson** have recently formed the consulting engineering firm of **Barry and Richardson** with offices in Tulsa. Aside to the many functions, the firm will offer engineering services as process and evaluation specialits.

Norman S. Morrisey is now a petroleum geologist with offices in Tulsa. He was formerly Drilling-Development Editor with the **Oil & Gas Journal** for the past four and one-half years. Prior to his publishing career, Morrisey was a petroleum geologist with **Pan American Petroleum Co., Stanolind Oil & Gas Co.** With Stanolind, he worked as a research geologist, area geologist and geophysical coordinator.

Norman S. Morrisey

Great Basins Petroleum Co., recently held a directors meeting in Denver, Colo., and the following men were elected officers: **R. G. Greene,** president; **M. H. Goforth,** vice president and secretary; **J. B. Clark,** vice president and treasurer and **M. F. Radspinner,** assistant secretary.

N. Patrick Hudson has been promoted to the post of sales manager of protective coatings for the **Lion Oil Co., Division of Monsanto Chemical Co.**

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Shell Oil Company has announced the transfer of three employees to the exploration and production area office in Tulsa. **Carl W. Mangus,** junior mechanical engineer, has been transferred from New Orleans, La., where he joined the production department's training program. **Harold J. Conrad,** junior exploitation engineer, was also at New Orleans prior to his assignment in Tulsa. **Albert R. Crawford,** senior draftsman, has been re-assigned to the exploration department after working in the Denver area office several years.

Norman Hardy

Fred A. Davies

Norman Hardy, president of **Arabian American Oil Company,** has been designated chief executive officer of that company. **Fred A. Davies** will continue as chairman of the board. Seven Aramco vice presidents also have been elected to the board of directors in a move to bring field management into greater participation in board affairs. They are **P. H. Arnot, T. C. Barger, R. I. Brougham, R. A. Eeds, R. S. Hatch, J. H. McDonald** and **L. M. Snyder.**

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Falmouth, Mass.—Walter S. Bennett, 5 Belvidere Road
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Narberth, Pa.—Worthington-Grothaus Associates, 105 Forrest Ave.
Omaha, Nebr.—Wm. Freiden, Central States Engineering & Sales Co., 5101 Blondo St.
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Portland, Ore.—J. G. Beard Co., 1233 NW 12th Ave.
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St. Louis, Mo.—Walter C. Dollinger Co., 4869 Goodfellow Ave.
Salt Lake City, Utah—Lovell Company, 29 E. 2nd St. South
Seattle, Wash.—Ashe & Jones, 819 Thomas St.
Wauwatosa, Wisc.—W. G. Nelson, P. O. Box 203

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DEATHS

George O'Leary, 65, president of **Houston Oil Field Material Co.,** died December 12 of a heart attack. O'Leary, in the oil industry for more than 40 years, joined HOMCO as a salesman in 1929. He had been its president since 1929.

Hu M. Harris, 82, recently named by the American Petroleum Institute as the "API Man of the Year," died December 14 at his home in Houston. Harris gained fame in the 1930s by designing **Humble Oil & Refining Co.'s** first unitized drawworks.

Howard A. Grimes, 56, retired Director of Creole Petroleum Corporation, died at a Florida hospital on October 27.

Dr. Louis Veillon, 84, the first employee of **Monsanto Chemical Company** when it was founded in 1901, died at his estate in Erlenbach-Zurich, Switzerland, on November 11.

Angus McLeod, 70, well known petroleum geologist and independent oil producer, died November 8 in Dallas, Texas. He had been associated with the **Roxana Oil Co.** and **Shell Oil Co.**

David R. Travis, 89, pioneer Oklahoma oil operator and philanthropist and president of **Gled Oil Co.,** died November 9 at Tucson, Ariz.

Arthur E. Barrus, 76, retired secretary-treasurer of **Sinclair Oil and Gas Co.,** died November 7 at his home in Tulsa, Okla., after a long illness.

James C. O'Mara, 76, retired drilling contractor of Bristow, Okla., died November 1 after a brief illness.

Lloyd F. Bayer, 64, senior vice president and director of Tidewater Oil Company died in an Oakland, California hospital, September 29.

James Roy Pringle, retired independent oil producer of Tulsa, died October 6 in Pittsburgh, Penn.

J. J. Young, president of the **J. J. Young** Drilling Co., died October 6 in a Columbus, Ohio, hospital.

Ralph Allen (Jack) Brant, 59, regional research geologist for the **Atlantic Refining Company,** died September 30. For seven years he taught subsurface geology night classes at the University of Tulsa.

Benton E. Warren, 59, manager of **Sun Oil Company's Latin American** production division, died Monday, November 10, in Bryn Mawr, Pa. Warren was also vice president and general manager of several subsidiary companies operating in Latin America. He was a member of the **American Petroleum Institute, Mid-Continent Oil & Gas Association** and the **Independent Natural Gas Association of America.**

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New Books, Maps and Movies

GEOLOGY OF PARKER COUNTY, TEXAS, The University of Texas, Bureau of Economic Geology, Austin, Texas, by Leo Hendricks, $1.50.

As the title indicates, this paper deals with the geology of Parker County, the surface rocks of which are Pennsylvanian, Cretaceous, Pleistocene and Recent geologic age. Stratigraphic classifications of Pennsylvanian beds and Cretaceous rocks exposed in the county are given, and six wholetone plates show Hill Creek limestone and ripple marks in sandstone; Meek Bend limestone beds; Brannon Bridge limestone beds; Grindstone Creek shale; Brazos River sandstone and conglomerate; Paluxy sand; and lower Trinity conglomeratic sands.

A detailed columnar section accompanies the geologic map which is on a scale of 1:62,500. This paper is a revision and completion of geologic field work begun some years ago by the late Dr. Gayle Scott.

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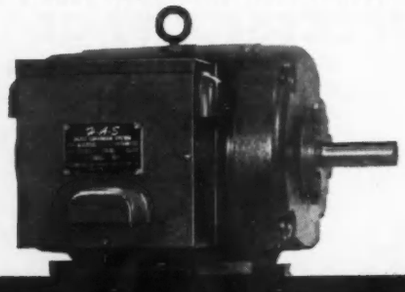

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A SURVEY OF SECONDARY RECOVERY AND PRESSURE MAINTENANCE OPERATIONS IN TEXAS TO 1956, Interstate Oil Compact Commission, Box 3127, Oklahoma City 5, $2.

This third survey in a similar series contains data on 194 secondary recovery and presure maintenance projects initiated between Jan. 1, 1954, and September, 1955, with data inclusive to Jan. 1, 1956, and supplemental data on 436 projects previously reported in 1952 and 1954 surveys.

In addition to the statistical data 40 new projects are described in somewhat more detail, together with graphs and field maps. Fifteen projects previously reported in the 1952 or 1954 reports are brought up to date by additional descriptive material.

THE 1958 EDITION OF THE MUNGER MAP BOOK, A. H. Munger, Munger Oilogram, 5865 West Blvd., Los Angeles 43, California, $20.

The 1958 edition of the Munger Map Book, containing complete maps of all California oil and gas fields updated to March 15, 1958, has recently been published. The book, measuring 11 by 18 inches, contains 190 pages of maps printed on a scale large enough for easy legibility of individual leases and wells. The cover is waterproof, plastic-coated stock on which is printed in two colors all fields of the state. On an inside cover, 2-color-map fields are identified and indexed to supplement the complete alphabetical index. A metallic binder permits pages to lie flat when opened.

Features added in this year's edition include a removable 6 by 10-inch clear vinyl map scale containing seven of the most frequently used scales used in books. Recent new fields and all current drilling wells as of March 15, 1958, also are shown.

THE OIL IMPORT PROBLEM, Fordham University Press, New York 58, N. Y., by Sebastian Raciti, $1.50.

The sixth in a series of studies in industrial economics by the Industrial Economics Program develops the oil import problem.

Beginning with the background of oil imports in 1870, the history is carried until current. Then the case is presented as two opposing viewpoints, that of the independents and that of the majors. The purpose of the book is to investigate the question of oil imports and their effect upon domestic oil production and thereby offer a clearer understanding of the problem.

MINERAL RESOURCES OF THE COLORADO RIVER INDUSTRIAL DEVELOPMENT ASSOCIATION AREA, Bureau of Economic Geology, The University of Texas, Austin 12, Texas, by John W. Dietrich and John T. Lonsdale, $1.50.

Amplified by illustrations and tabular information, this 84 page booklet is a compact discussion of the mineral resource materials in a ten-county area in the lower watershed of the Colorado River.

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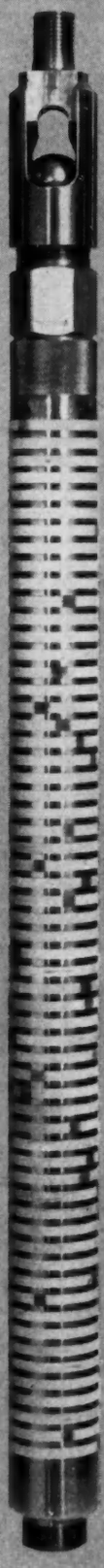
is the real villain in sucker rod pump troubles. It accounts for most of your repair and pump pulling expense.



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for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

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The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

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EUROPE'S NEED FOR OIL—Implications and Lessons of The Suez Canal, OEEC Publications Office, 2000 P. Street N W, Washington 6, D. C., Price $1.75.

A concise and interesting discussion of the background, experience and future lessons owing to the blocking of the Suez Canal and its impact on the economy of Western Europe is unfolded in a 106-page paper-bound volume.

Also included in the publication is the discussion of the cumulative effect of the resulting oil shortage on the Organization for European Economic Cooperation nations, with emphasis on the cooperative program which worked very well to effect distribution of available supplies to satisfy each participating country's individual fuel needs. Less known factors in the success of the OEEC effort, such as the unusually mild winter of 1956-57 and greater availability of hydroelectric power due to the less severe freezeup, are also discussed.

OIL AND GAS IN THE FOUR CORNERS, National Petroleum Bibliography, Amarillo, Texas. Compiled and Edited by Paul J. Kuhn.

"Oil and Gas in the Four Corners" brings out the pertinent field data in the counties involved in the four states of Arizona, Colorado, New Mexico and Utah.

Maps, geological notes, development-production data, discovery data are presented in the book.

More Books on Page 300

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Oilmen everywhere are getting acquainted with JENSEN's new Rotary-Balanced Jack, engineered and designed to assure *extra years* of rugged, on-the-job service.

It's perfectly balanced to give you maximum efficiency at a lower cost. Long, smoother strokes—no mater how deep your well.

And it's the easiest of all to counterbalance. Just one man—standing on the ground—can adjust this new JENSEN JACK, *without* any special equipment.

STOCKED BY YOUR LOCAL SUPPLY STORE

Made by JENSEN BROS. MFG. CO., INC., P. O. Box 477-D, Coffeyville, Kansas

Export Office: 250 Park Avenue, New York 17, N. Y.

JENSEN JACKS

WHO'S MEETING WHERE

1959 JAN. 12–16	SAE Annual Meeting & Engineering Display, The Sheraton-Cadillac & Hotel Statler, Detroit, Mich.
FEB. 1–4	AAPG, Rocky Mountain Section, Civic Auditorium, Albuquerque, New Mexico.
1–6	AIE, Statler, Sheraton & McAlpin Hotels, New York.
2–27	Southwestern Legal Foundation, Short Course on Oil and Gas Law, Southwestern Legal Center, Dallas.
11–12–13	NACE, Tulsa Section, Tenth Annual Pipe Line Corrosion Short Course, Mayo Hotel, Tulsa, Okla.
11–13	Southwestern Legal Foundation, 10th Annual Institute on the Law of Oil, Gas and Taxation, Southwestern Legal Center, Dallas.
15–19	AIME, Annual Meeting, San Francisco, Hotels St. Francis, Sheraton-Palace, Sir Francis Drake.
24–25	Geological Symposium, The University of Oklahoma, Norman, Okla.
MAR. 4– 6	API Division of Production, Southwestern District, Scharbauer Hotel, Midland, Texas.
16–19	AAPG, 44th Annual Meeting, Statler Hilton, Dallas.
17–21	NACE, National Meeting, Civic Auditorium, San Francisco.
25–27	API Division of Production, Southern District, Roosevelt Hotel, New Orleans.
31– Apr. 2	Power Conference, Illinois Institute of Technology, 21st American Power Conference, Hotel Sherman, Chicago.
APRIL 5– 9	Nuclear Congress, Engineers Joint Council, Cleveland, Ohio.
8–10	API Division of Production, Eastern District, Spring Semi-Annual Meeting, Penn-Sheraton Hotel, Pittsburgh, Penn.
20–24	Petroleum & Chemical Industry Short Courses, Safety Engineering, University Downtown Center, Lockett Hotel, the University of Oklahoma, Norman, Oklahoma.
22–24	API Mid-Continent District Meeting, Herring Hotel, Amarillo, Texas.
26–28	TIPRO, 14th Annual Meeting, Baker Hotel, Dallas.
27–28	Petroleum & Chemical Industry Short Courses, Automatic Control, Oklahoma Memorial Union Building, University of Oklahoma, Norman, Okla.
30– May 1	API Division of Production, Pacific Coast District, Biltmore Hotel, Los Angeles.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Secretary.

SINCE 1921

LubriKup

FIRST... in step with a progressive, ever modernizing industry!

All research and development of the LUBRIKUP Company has been devoted to the manufacture of composition cups to meet the varying conditions of pumping oil. With the single purpose of delivering the best product that research and science can produce, we pledge to our customers and the supply stores that help us serve these customers that we will never be satisfied with making anything but the best cups possible.

LUBRIKUP COMPANY, INC.

LUBRIKUP FIRST! ... to devote their entire activity exclusively to the manufacture of composition cups and cup-type packings for the oil industry!

LUBRIKUP FIRST! ... to recognize that pumping conditions varied with depth of wells and types of fluid, necessitating soft, medium and hard cups for particular conditions and areas!

LUBRIKUP FIRST! ... to develop the reverse bevel seating cup and seating assembly — now standard equipment with all leading pump manufacturers!

LUBRIKUP FIRST! ... to adopt composition cups to reciprocating pumps and furnish pressure seal pistons for converting them from ring or packed type to cup type — and then improved them further by making Type H Pressure Seal Pistons, the newest and most improved design!

LUBRIKUP FIRST! ... to originate the now accepted method of packaging valve cups (four matched cups to a box) to assure their factory-condition receipt in the field!

LUBRIKUP FIRST! ... to introduce the new Fluid Seal Rod Packing which gives longer packing life, less rod wear and increased pump efficiency!

LUBRIKUP FIRST! ... to offer valve cups with a 45° bottom, designed with a heavier side wall to give additional strength and longer wear, providing greater support at the heel to eliminate breakdown at the bottom of the cup!

LubriKup

- VALVE CUPS
- WOOD-TYPE VALVE CUPS
- SEAT CUPS
- SEAT RINGS
- JERKERKUPS
- PRESSURE SEAL PISTONS
- COMPOSITION RINGS
- JACK CUPS
- FLUID SEAL ROD PACKING
- NON-ADJUSTABLE PACKING

Integrity — Skill — Research
STANDARD OF QUALITY

there's a LubriKup *for every service*

and service with every LUBRIKUP!

— AT YOUR FAVORITE SUPPLY STORE —

LUBRIKUP COMPANY, INC.

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EXCLUSIVELY MANUFACTURING COMPOSITION CUPS FOR THE OIL INDUSTRY

—Oil Field Representatives—

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Another DARCOVA first!

100% NYLON COMPOSITION

DARCOVA VALVE CUPS, SEATING CUPS, AND SEATING RINGS

—long noted for outstanding performance in well pumping—are now available in 100% nylon composition for *extra* strength, *extra* life!

They are offered in the full range of precision sizes and Darcova textures that assure peak efficiency under varying conditions of depth, pressure, temperature, corrosion and abrasion.

So be sure to specify

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The *original* . . . and *always* the best!

DARLING VALVE & MANUFACTURING COMPANY

DARCOVA ®

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THE ORIGINAL COMPOSITION CUP

What's Happening

among SERVICE and SUPPLY MEN

R. E. Batchelor

W. J. Bovaird

J. E. Goodell

D. L. Dufford

The Bovaird Supply Company recently announced four important changes in that firm's organization. **R. E. Batchelor,** who was vice president and manager of sales, has been promoted to vice president and general manager of sales. **W. J. Bovaird,** who was formerly general manager of stores, was promoted to sales manager. **J. E. Goodell,** who was a former assistant to the general manager of stores, has been made general manager of stores and **D. L. Dufford,** a former assistant to the general manager of stores, is now coordinator of Purchasing and Pricing departments.

Emmett A. McCoppin has recently joined the **Willis Oil Tool Company** as a District sales representative for the Louisiana and Missisippi area.

Oilfield Pty. Ltd., Sydney, N.S.W., Australia, announced the formation of the new company which is reported to be the first and only supply company in Australia offering "over the counter" sales to the industry.

L. B. Swan has been named to the post of vice president of the **Dowell Division of The Dow Chemical Company.** Formerly general manager of Dow's Brazos Oil and Gas Division, Swan will head a Houston office which will be primarily responsible for Dowell's foreign operations. **Tromer R. Smith,** general manager in Venezuela of United Oilwell, a Dow subsidiary, will move to Houston early this year to supervise Dowell's Latin American activities. **Basil A. Hodges,** United Oilwell operations manager, will replace Smith.

D. W. Boyles has been appointed assistant purchasing agent for the **Northwest Division** of **The National Supply Company.** He will have his headquarters in Casper, Wyo. He has been in the division merchandising department, at Denver, since August, 1957. In his new position, Boyles will handle all emergency purchasing in the Casper area for the company's oil field supply stores in the Northwest Division.

Louis G. Helmick, Jr., executive vice president of **Joy Manufacturing Company,** has been elected a director of the company. Helmick, who joined Joy in 1947, was elected executive vice president in June, 1958. Prior to that time, he had served as vice president and general manager of Joy's Industrial Division. Earlier, he had been vice president for manufacturing, manager of manufacturing, works manager of Joy's Claremont, New Hampshire works, and assistant works manager of the company's Franklin, Pennsylvania works.

Dick M. Koons has been appointed director of the research and development department for **Otis Engineering Corp.** in Dallas. Koons was with the Cia Shell de Venezuela in Maracaibo for the past 13 years as senior production engineer. Prior to his employment with Shell, he was with Geologic Standards and The Texas Company, both in Tulsa. He is a member of the Society of Petroleum Engineers of AIME and was one of the founders of the local chapter in Maracaibo. He is also a member of the American Petroleum Institute. Koons is assuming the duties of **Harry B. Schramm,** former Otis vice president of research and development.

Dick M. Koons

BJ Service has named **C. C. B. Moody** as assistant to the vice president of engineering and development, **M. B. Riordan.** From his office in Long Beach, Moody will help direct BJ research and development activities there and in Breckenridge, Texas.

H. A. Woodard

F. D. Sawyer

Wexlex, Inc., has announced the promotion of two men to division managers. In charge of Wexlex's California division, with offices in Los Angeles is **H. A. Woodard**, former division sales manager. The new Rocky Mountain division manager at Denver is **F. D. Sawyer**, formerly assistant sales manager in Fort Worth.

Lone Star Steel Company has announced the promotions for two employees of the Dallas office. **Charles R. (Dick) Hatcher** has been named supervisor of the steel pipe pricing section of the sales department. **Sonny Ogden** who joined the company as an order clerk in 1953 has been appointed supervisor of the steel pipe order section.

The Clevite Corporation, Texas Division, has announced the appointment of **Charles (Pete) Caldwell** as assistant general manager. He will retain his responsibilities as sales manager, a position he has held since 1956.

Charles (Pete) Caldwell

Bethlehem Supply Company announces the following personnel promotions and transfers within that organization.
V. H. Prange, Jr., formerly field representative at Charlotte, Texas, has been transferred to Corpus Christi, Texas, in the same capacity. Prange will extend his efforts primarily on production equipment sales. **M. E. McFarland**, formerly store manager at Medicine Lodge, Kansas, has been transferred to Liberal, Kansas, as field representative. **H. H. Huslig** has also been transferred from Medicine Lodge to Great Bend and promoted to field representative. **M. F. Misejka** has been promoted to field representative at El Dorado, Kansas. McFarland, Huslig and Misejka will call on both drilling and production field accounts in their respective store areas. **C. W. Blackstun** has been transferred from the Tulsa sales office to the New Orleans district office and promoted to machinery sales representative.

Philip A. Roth has been elected to the board of directors of **U. S. Industries, Inc.** Roth is chairman of the executive committee, executive vice president and a director of General Industrial Enterprises, Inc. He is chairman of the executive committee, vice president and a director of Baldwin Securities Corporation.

W-K-M, a Division of ACF Industries, Inc., has confirmed the appointment of **Glen Tableman** as manager of W-K-M Valve Co. (Britain) Limited, which was announced recently by the board of directors of the W-K-M Valve Co. (Britain) Limited in London, England. Tableman was previously general sales manager of the W-K-M Division in Missouri City, Texas.

Howard S. Bean, formerly with the National Bureau of Standards, Washington, D. C., has joined **Daniel Orifice Fitting Company** as a flow measurement consultant.

Burton McCollum, head of McCollum Exploration Company, Houston, was honored recently by the **Society of Exploration Geophysicists** at that group's annual meeting in San Antonio. He was presented with a lifetime membership in the SEG, the highest honor which can be bestowed upon an individual by this group. The presentation was made by **Dr. Sigmund Hammer, Gulf Research and Development**, Pittsburgh.

Burton McCollum

Oil Well Supply Division of U. S. Steel has announced three important appointments and one transfer. The appointments are: **John Rice**, field representative at the Valleyview, Alta., Canada store; **William A. Pratz**, manager of the Victoria, Texas, store and **D. H. Schoonover** as field representative at Hobbs, N. M. The one transfer is **L. Hamilton Shaw**, assistant district engineer at Farmington, N. M., who will now make his office in Fort Morgan, Colo.

Calvin L. Wright was recently appointed field service engineer for **A. M. Byers Company** of Baltimore, Md. Wright succeeds V. H. Ross who retired last September 1.

R. D. Ford has been named president of **Schlumberger Surenco, S. A.** Ford, as chief of the Schlumberger company which operates in South America, will continue to maintain headquarters in Caracas, Venezuela. He has held a number of posts in various parts of this country, including Assistant Area Manager in California, Assistant Area Manager for the Gulf Coast with headquarters in Houston, and Area Manager for the Mid-Continent area. Until his recent promotion, Ford was Executive Vice President of Schlumberger, having held that position since 1952.

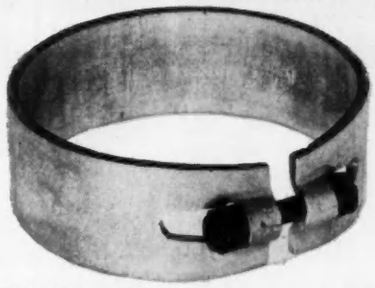
R. D. Ford

DON'T WELD ON CASING!

B and W

FRICTION-LOCK CLAMPS

give you these distinct advantages in mounting scratchers and centralizers:



LOWER COST . . . Friction-Lock Clamps cost less than welding when ordered with B and W Scratchers and Centralizers.

WITHSTANDS GREATER THRUST . . . exhaustive laboratory tests prove Friction-Lock Clamps withstand resistance to vertical movement far in excess of average field welding.

ELIMINATES WELDING DAMAGE . . . average field welding may damage casing from undercutting, hard spots and electrolytic corrosion . . . Friction-Lock Clamps cannot damage casing.

ONLY FULL GRIPPING DEVICE . . . only the Friction-Lock Clamp grips uniformly around the complete periphery of the casing . . . other holding devices grip over relatively small areas.

EASIER INSTALLATION . . . B and W Friction-Lock Clamps may be installed in seconds with a simple hex wrench.

ANOTHER FIRST BY THE FIRST NAME IN PRIMARY CEMENTING TOOLS

OTHER B and W PRODUCTS:

Multi-Flex Scratchers • Nu-Coil Scratchers • Rotating Scratchers, Multi-Flex and Nu-Coil Types • Automatic Stop Collars • Stabilizers • Rotator Collars • Liner Centralizers • Latch-On and Solid Type Centralizers • Thread-Lock Cages • Thread-Lock Cement.

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Well Completion Specialists

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For more data on advertised products, use Readers' Service Cards, last page.

M. W. (Cy) Reed has been promoted to foreign operations manager—western hemisphere for **Halliburton Oil Well Cementing Co.** Reed has been in charge of Halliburton's Canadian subsidiary since 1948 and had earlier spent seven years in foreign oil fields. He plans to move from Calgary, Alberta to the company's Duncan, Okla., headquarters.

M. W. (Cy) Reed

H. B. (Pat) Hurley, formerly an executive with Continental Oil Company and more recently senior vice president of Republic Natural Gas Company in Dallas, has now joined **Welex, Inc.** as assistant to the president. Hurley, whose whole lifetime has been spent in the oil industry, will headquarter in Houston.

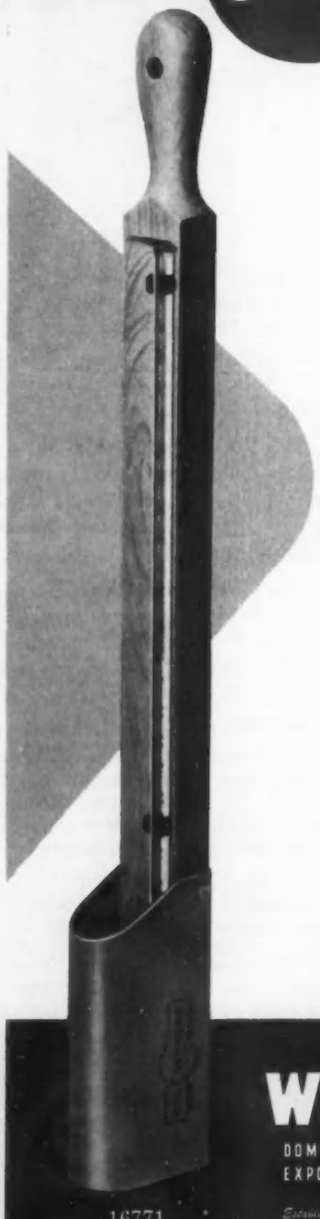
H. B. (Pat) Hurley

United Geophysical Corporation has made the following announcement of new appointments: **Flint Agee** has been appointed as manager of North American Operations for United Geophysical Corporation. Agee is also a director of the corporation and has been closely associated with the geophysical industry for 22 years, the last 15 being with United. **William P. Patterson** has been appointed vice president and general manager of **United Electro-Dynamics,** a division of the corporation which manufactures a line of electronic instrumentation, both for the geophysical industry and defense. **Frederick K. van Biene** has assumed the duties of manager, **United Testing Laboratories,** another division, engaged in environmental, reliability and qualification testing for defense and industry.

CURTIN

API TANK THERMOMETERS

with "EVERLAST"
Fused-in Graduations



- **Permanent Graduations**—are etched in the glass, and filled with special pigment. Extra processing actually fuses the pigment into the glass so that it becomes a permanent part of the thermometer. Unaffected by oils or any other liquid not harmful to glass, "EVER-LAST" graduations can never fade, peel, or dissolve.
- **Guaranteed Accurate**—to within one scale division. Seasoned and annealed to assure permanent accuracy.
- **Easy to Read**—the mercury column appears red when viewed through the lens-type scale.
- **Finest Hardwood Case**—chosen from select hardwoods, cases are accurately made and finished smooth; resist warping and cracking. Friction clips hold tight, but permit easy exchange of tubes so that all ranges may be used. All metal parts are non-sparking.
- **Meets API and ASTM Specifications**—the provisions of API Standard 2500 and ASTM Specification E-1 are fully met by Curtin tank thermometers with "EVER-LAST" fused-in graduations.
- Available in ranges of —30 to +120° F., 0 to 180° F., 20 to 260° F. and 170 to 500° F.

For immediate shipment.

Write for free copy of 24-page Catalog G-56 Petroleum Gaging Equipment.

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W. H. CURTIN & CO.

DOMESTIC EXPORT • CURTIN

PETROLEUM TESTING EQUIPMENT

HOUSTON - DALLAS - NEW ORLEANS - JACKSONVILLE

Sales Offices: TULSA - BIRMINGHAM - CORPUS CHRISTI

Subsidiary: CURTIN DE MEXICO, S.A. de C.V., MEXICO CITY

Established 1922 U.S.A.

Bethlehem Supply Company announces that **L. C. Graves,** formerly in charge of subsurface equipment sales for **Bethlehem's Gulf Coast Division** at Houston, has been promoted to special representative — subsurface equipment, at Tulsa. His new responsibilities will be promotion of sales for Bethlehem Beeline subsurface pumps and Bethlehem sucker rods covering field activities in all areas where Bethlehem has local stores.

L. C. Graves

Gordon W. Wilson, formerly production superintendent for **Phillips Petroleum Company** in Venezuela, has been named manager of the company's operations in British Honduras with headquarters in Belize.

Robert B. McQuarrie of Seattle, Wash., has been named Northwest Coast field service engineer for **A. M. Byers Co.,** with headquarters in the Russ Building, San Francisco.

L. J. Prior

Wm. T. Hoffman

Louis J. Prior has been appointed traffic manager, machinery division, and **William T. Hoffman** traffic manager, tubular division, by **The National Supply Company.** In their new positions, these men will divide the responsibilities formerly held by **John N. Lind** as general traffic manager. Lind recently was named director of transportation for **Armco Steel Corporation,** of which National Supply is a subsidiary.

Charles E. Langdon, manager of the land and lease deparmtent of **Newmont Oil Co.,** at Midland, Texas, has been elecetd a vice president at Fort Worth.

J. T. Calnon is the new president of **Cummins Sales & Service, Inc.** He was formerly vice president-sales for the Fort Worth firm.

J. T. Calnon

H. F. Nostrand

H. F. Nostrand has been appointed advertising manager of **W. C. Norris, Manufacturer,** division of Dover Corporation of Tulsa.

These two pictures were inadvertently transposed in the November, 1958, issue of WORLD OIL.

Henry A. Ruysser, Jr., executive vice president of **Black, Sivalls & Bryson, Inc.,** announced that headquarters for sales management of BS&B's oilfield equipment division have been established at Houston, with the transfer of **Floyd C. Myers,** vice president and manager of Oilfield Sales & Service, to that location. All other Oilfield division departments remain headquartered at Oklahoma City.

Phillip G. Jackson has joined **Rector Well Equipment Co., Inc.,** as sales engineer in the Rocky Mountain area, it has been announced. Jackson will maintain headquarters for Rector in Casper, Wyo.

C. J. Spivey has joined the **Petty Geophysical Company** of San Antonio, Texas in its Foreign Exploration Department. He formerly was manager of Venezuelan operators for Geophysical Service, Inc., of Dallas.

Rector Well Equipment Co., Inc., of Fort Worth, Texas, has announced these changes in personnel operations. **Charles Zartman,** who has been serving both as chief engineer and assistant to the president, will devote full time to the position of assistant to the president. Replacing Zartman as chief engineer is **George Garrett,** who was formerly development engineer of the firm. In the third move, **John L. Curry** was named to the newly created position of sales coordinator. He formerly was sales manager of the cementing equipment division. Zartman has been with Rector Well Equipment Co. for 27 years. He has been active in the engineering and design of high and low pressure wellhead products and cementing equipment that made history in the oil industry.

Arthur R. Pitkin has been appointed as purchasing agent by **Tex-Tube, Inc.** Pitkin will be responsible for purchasing all maintenance supplies and raw materials for production.

Joe McGraw, Jr. has joined **Security Engineering Division** as a regional sales representative. The company, manufacturer of rock bits and related oil well drilling tools, has recently opened an office in Tulsa, Oklahoma, where McGraw will make his headquarters.

Robert S. Wright has been named president of the **USI International,** a division of **U. S. Industries, Inc.** Wright's first duties will be to initiate and direct an intensive program to expand the operations of USI International and to extend its services into additional overseas areas.

Sterling Packing & Gasket Co., Inc., recently announced two new appointments. **Charles Fay** has been appointed sales manager and **Robert B. Allen,** appointed sales representative.

Charles Clark has been named sales engineer for the Clark Pittsburgh office of **Clark Bros., Co.** He is the third generation descendent of the original founders of the company.

H. L. Moschel, former central division manager of **Eastman Oil Well Survey Company,** has been named recently as the new manager of the southern division. He is moving from Dallas to Houston where offices are set up. The southern division includes Texas, except the Panhandle, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina and the southern half of Arkansas and New Mexico.

Wallace L. Reed, U. S. Steel Oil Well Supply Division district engineer, has been transferred from Houston to Jackson, Miss., it has been announced.

Continental-Emsco announces four personnel promotions and appointments.

H. E. Lowrey has been promoted to the position of vice president, Export Division. In his new position Lowrey will have

FOR USE IN DRILLING OPERATIONS

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SPANS THE WORLD

'KIRKOSE' SODIUM CARBOXYMETHYL CELLULOSE • USED ON A WORLD-WIDE BASIS FOR FLUID LOSS PREVENTION • AVAILABLE IN LOW AND HIGH VISCOSITY GRADES • SALT RESISTANT SUITABLE FOR BRINE MUDS AS WELL AS FRESHWATER MUDS

" In certain Countries of the world the use of S.C.M.C. for drilling operations is covered by patent rights, in connection with which we are empowered to grant licences. In sales for use in these countries (U.S.A., Canada, Mexico, Iran, Colombia, Iraq, Brazil, France) we pay a royalty to Drilling Specialities Company, Bartlesville, Oklahoma, of 7c. per lb. actual S.C.M.C., which is included in our selling price. In consequence, drillers in these countries are licensed to use our product for any drilling operations."

CABLE 'KIRKSYL' BURY, ENGLAND. SAMPLES & FULL TECHNICAL LITERATURE WILL BE FLOWN OUT TO YOU ANYWHERE—IMMEDIATELY

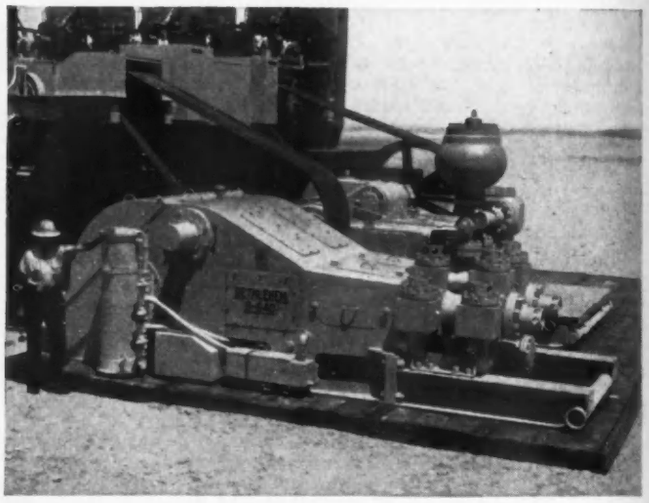
Issued by the Chemical Division of KIRKLEES LTD., BURY, ENGLAND

IT'S BEEN A GREAT HUNDRED YEARS!

Here at Bethlehem, we like being part of a worldwide industry that is now one century old. It's been a great hundred years since Col. Drake's discovery well—a century of amazing development and growth for Petroleum. Bethlehem has shared in that growth, and we warmly appreciate the industry's acceptance of our products and services.

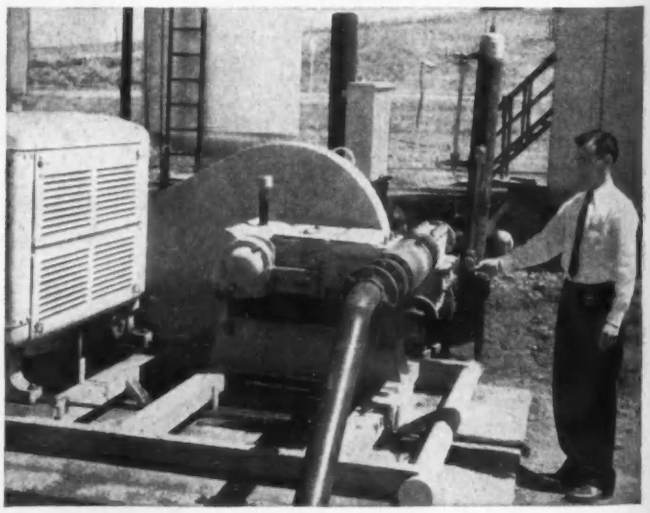
Bethlehem-built equipment is widely used today in shallow- and deep-well drilling; in beam-type pumping; in waterflood, pipeline, and other kinds of work. All products are available in a complete range of sizes. The illustrations on this page show typical Bethlehem units.

B-3661 DRAWWORKS. Bethlehem's biggest, most powerful. Designed and built for the deepest holes ever drilled (25,000 ft or more). Obtainable with two-speed transmission for electric-motor or steam-engine drive; also with three speeds and reverse for internal-combustion-engine drive. Recommended input hp to transmission—2100. Additional hp capacity can be provided to drive auxiliary equipment.



B-1640 POWER PUMP. Companion-piece to Bethlehem's B-3661 drawworks. Delivers tremendous hp to the bit, thereby increasing rates of penetration, even in deepest drilling. Eliminates need for parallel or series operation. Fluid end is an assembly of heavy steel forgings; power end an all-steel weldment with double-plate construction.

160D PUMPING UNIT. One of many popular sizes. Bethlehem units range in capacity from 6,000 to 640,000 in.-lb torque; handle polished-rod loads from 2,000 to 33,000 lb. Features include adjustable rotary counterbalance with safety lock; hydraulically removable wrist pins; roller-bearing gear-reducer; step-down walking beam. All types of prime movers and prime-mover extension bases available.



TP-4 TRIPLEX PUMP. This sturdy plunger pump, shown here on a waterflood project, is one of three triplex models made by Bethlehem. TP's are recommended not only for waterflooding, but for salt-water disposal, crude- and lean-oil service, and numerous other jobs. Bethlehem also offers three sizes of duplex piston-type general-service pumps.

New $500,000 Home for Milwhite Mud Sales Co. Planned

Milwhite Mud Sales Company has started construction on a new administrative, general offices and laboratory costing in excess of $500,000. Shown giving approval of the working plans, left to right, are: Homer R. Wells, vice president in charge of production; George E. Conner, executive vice president; Sidney A. Adger, vice president in charge of public relations, Milwhite Mud Sales Company and E. N. Bensen, president, Bensen Company Builders. The new building which will contain 20,000 square feet of floor space, in addition to replacing administrative offices now located in the Bank of the Southwest Building, Houston, will house one of the newest and most modern mud research laboratories available to the oil industry today.

operating supervision of Continental-Emsco's Export Division. The Export Division includes the Houston and London export offices, and three stores and two offices in Venezuela.

J. Allen Whitesides has been appointed to the position of sales and development Engineer-Drilling Equipment. In his newly created post, Whitesides will work closely with Continental-Emsco's distribution, engineering and manufacturing personnel on new equipment development and research.

Max M. Marstrand has been appointed to the position of Division Merchandise Manager with headquarters in Tulsa. **Henry Hobbs, Jr.**, will fill the same position at the oil field supply and manufacturing company's Houston division office.

George D. Doremus, who joined the **George E. Failing Company** of Enid, Oklahoma, earlier this year as works manager, has been elected vice president in charge of manufacturing. The Failing Company is a subsidiary of Westinghouse Air Brake Company of Pittsburgh, Pa.

Charles B. Barry, Tulsa, and **J. A. Richardson**, Dallas, have announced the formation of a new consulting engineering firm, **Barry and Richardson.** The new firm will offer a complete range of engineering services as process and evaluation specialists to the petroleum, natural gas and chemical industries.

Oil Center Tool Company has created two new vice presidents and appointed two regional sales managers. **C. Ross Spencer** has been named vice president and manager, foreign marketing, and **Charles T. Jones** is the new vice president and sales manager. Spencer formerly was sales manager, while Jones was assistant sales manager. New regional sales managers are **M. E. (Mike) Hunter**, for the eastern region, and **A. C. (Bus) West, Jr.**, for the western region. All will have headquarters offices in Houston, Texas.

Cooper-Bessemer Announces Creole as Texas Subsidiary

Acquisition of Creole Engineering, Inc., Houston, as a new wholly-owned manufacturing and engineering subsidiary, has been announced by The Cooper-Bessemer Corporation.

Final negotiations for the acquisition have been completed, and the entire Houston operation is to be headed by T. E. Kraner as president. Kraner was formerly district manager of Cooper-Bessemer's Caracas, Venezuela, office, and more recently of the New Orleans office.

B and W, Inc. Opens New Louisiana Warehouse

B and W, Inc. has recently opened a new warehouse and service center in Morgan City, La., which is located in the Kyle-Taylor-Wyandotte Yard area.

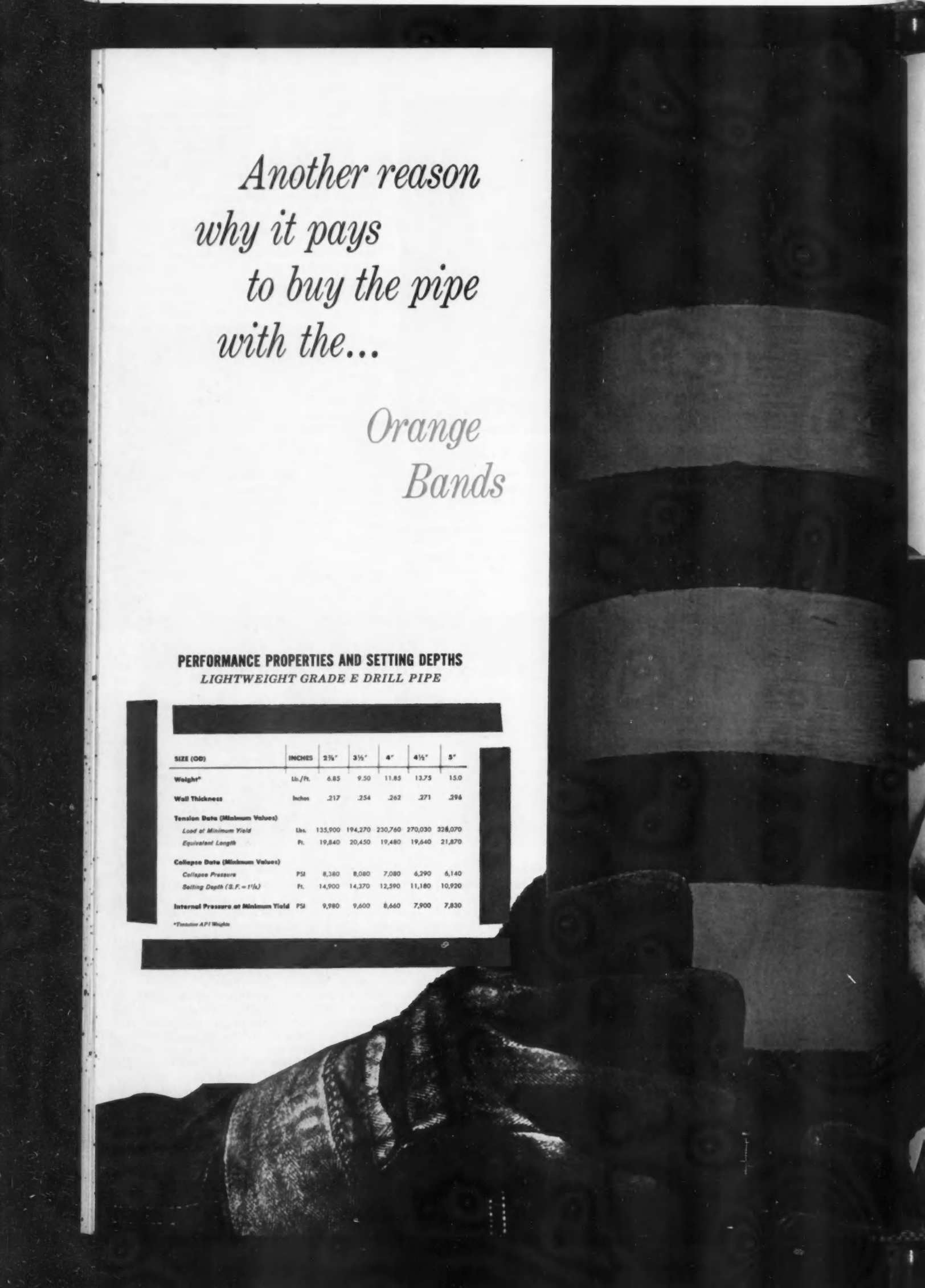
The new warehouse will provide prompt delivery and installations of B and W scratchers, centralizers and holding devices to barge, offshore and land locations in the south central Louisiana area. B and W warehouses in Harvey and New Iberia will continue to serve these respective areas. The new Morgan City warehouse will be under the supervision of J. L. Felts, Eastern district manager for B and W, Inc.

School of Production Technology Gets First-Hand Look

Brown Oil Tools, Inc., recently hosted 26 men from the School of Production Technology in Kilgore, Texas, as the group got a first-hand look at the latest completion practices. Field trips are a part of the curriculum of the School of Production Technology which is jointly sponsored by the API Division of Production and the Petroleum Extension Service of the University of Texas. Those students on hand for the inspection tour, seated left to right, are: George M. Martin, Cabot Carbon Company; John J. Larkin, III, Larkin Packer Company, Inc.; George Palmer, Southwest Natural Production Company; Grayson C. Smith, Magnolia Petroleum Company; Hoyt N. Berryman, Jr., Arcadia Refining Company; William C. Cheatham, Mene Grande Oil Company; Gus E. Talbott, Shell Oil Company; Ross W. Muir, Shell Condor; Merle A. Beeson, Socony Mobil de Venezuela; Kenneth R. J. Trott, Kuwait Oil Company, Ltd.; Louis M. Schischikowsky, Shell Oil Company of Canada, Ltd. Standing from left to right are: Bill B. Cotton, Larkin Packer Company; Howard M. Johnson, Tennessee Gas Transmission Company; Pieter Schoe, Cia Shell de Venezuela; William Miskimins, Jr., Tennessee Gas Transmission Company; Carl H. Bilbrey, Honolulu Oil Corporation; Pedro Jacinto Anon, Mene Grande Oil Company; Pablo Alfonso Jimenez, Creole Petroleum Corporation; W. E. Harmon, Jr., Creole Petroleum Corporation; Gaston Gaal, Blue Danube Oil Company; Robert J. Nelson, H. W. Bass & Sons, Inc.; Robert A. Gordon, Apex (T'dad) Oilfields, Ltd.; Glen D. Bullock, Jersey Production Research Company; William M. Hitchcock, Blue Danube Oil Company; Cyrus O. Turner, Magnolia Petroleum Company; Ronald E. Preston, Caltex Pacific Oil Company.

Another reason why it pays to buy the pipe with the...

Orange Bands



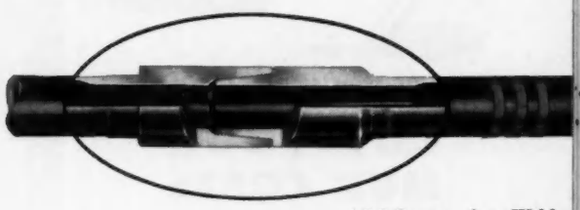
PERFORMANCE PROPERTIES AND SETTING DEPTHS

LIGHTWEIGHT GRADE E DRILL PIPE

SIZE (OD)	INCHES	2⅞"	3½"	4"	4½"	5"
Weight*	Lb./Ft.	6.85	9.50	11.85	13.75	15.0
Wall Thickness	Inches	.217	.254	.262	.271	.296
Tension Data (Minimum Values)						
Load at Minimum Yield	Lbs.	135,900	194,270	230,760	270,030	328,070
Equivalent Length	Ft.	19,840	20,450	19,480	19,640	21,870
Collapse Data (Minimum Values)						
Collapse Pressure	PSI	8,380	8,080	7,080	6,290	6,140
Setting Depth (S.F. = 1¹/₆)	Ft.	14,900	14,370	12,590	11,180	10,920
Internal Pressure at Minimum Yield	PSI	9,980	9,600	8,660	7,900	7,830

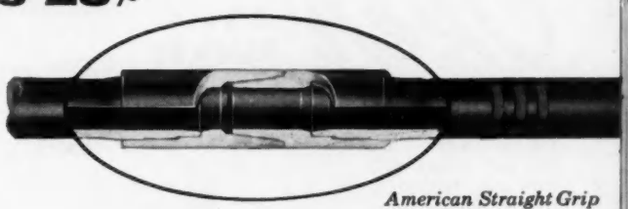
*Tentative API Weights

YOUNGSTOWN LIGHTWEIGHT DRILL PIPE

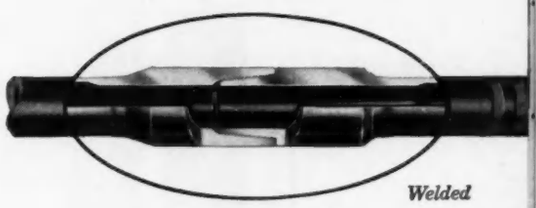


API Counter-bore Weld

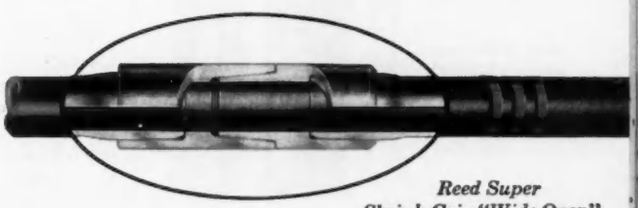
Extends drilling depth, reduces hoisting loads 25% —with your present rig



American Straight Grip



Welded



Reed Super Shrink-Grip "Wide Open"

Hughes Seal Grip

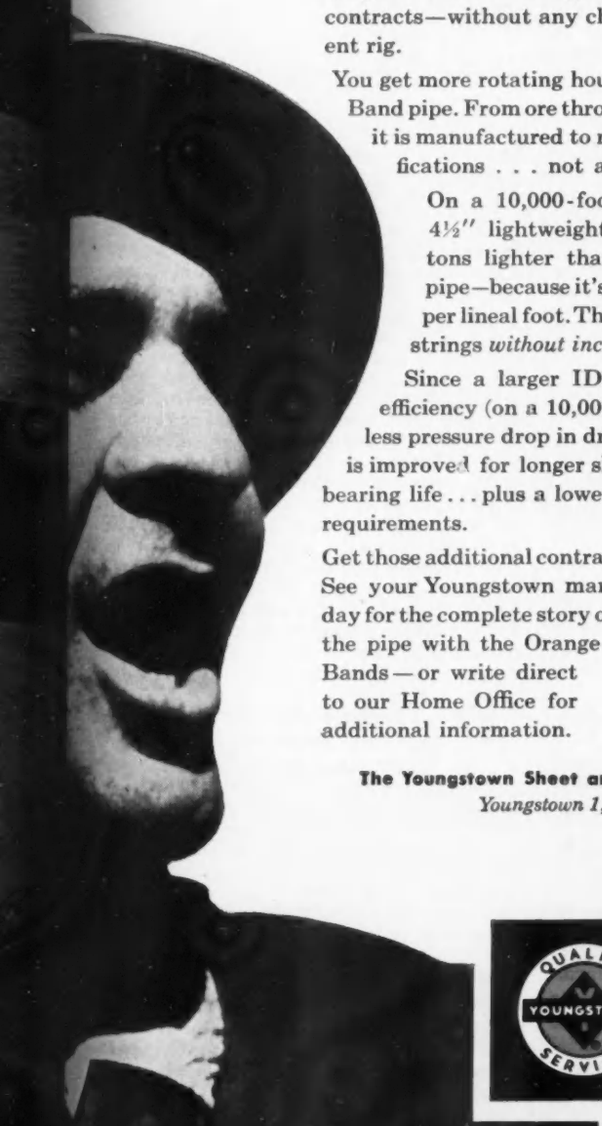
Now, Youngstown provides a lightweight drill pipe that will substantially extend your bidding range. You can bid and *get* those deeper drilling contracts—without any changes in your present rig.

You get more rotating hours with this Orange Band pipe. From ore through final inspection, it is manufactured to rigid drill pipe specifications . . . not a tubing substitute.

On a 10,000-foot hole, a string of 4½" lightweight drill pipe is 14¼ tons lighter than 4½" regular drill pipe—because it's 2.85 pounds lighter per lineal foot. This means longer drill strings *without increased weight.*

Since a larger ID is used, hydraulic efficiency (on a 10,000-foot string, 16.7% less pressure drop in drilling fluid column) is improved for longer slush pump rod and bearing life . . . plus a lowering of horsepower requirements.

Get those additional contracts now. See your Youngstown man today for the complete story on the pipe with the Orange Bands — or write direct to our Home Office for additional information.



The Youngstown Sheet and Tube Company
Youngstown 1, Ohio

Youngstown Lightweight Drill Pipe
Is Available Threaded or Plain End, Internal or External Upset for Attachment with Above Tool Joints.

QUALITY YOUNGSTOWN SERVICE

Youngstown

SEAMLESS DRILL PIPE • CASING • TUBING

DON'T LET THIS HAPPEN TO YOU!

AVOID COSTLY ACCIDENTS AND

CUT YOUR MUD COSTS

WITH AN

Okeh MUD SAVER BUCKET

When breaking out on "wet" jobs, simply clamp an OKEH Mud Saver Bucket around the drill pipe to enclose the tool joint. The bucket traps all mud and returns it to the ditch.

Costly mud is saved — derrick floors are kept dry and safe.

Open Position

Mud Bucket complete, $240.00. Additional sealing members, $18.00 per set.

Replaceable end and side sealing rubbers prevent leakage, and buckets are adaptable to any size drill pipe by simply changing the sealing members.

Also available is

THE OKEH OIL SAVER BUCKET

It is simply a miniature of the larger tool, operates in the same way, with the same saving features—*but for saving oil.* When breaking out on wet oil jobs, simply clamp suspended OKEH OIL SAVER BUCKET around tubing collar to be broken out. 6" metal body, 48" long, equipped with 3" discharge hose.

Oil Saver Bucket complete $175.00
Weight, 105 lbs.

Complete extra set of end seals 10.00

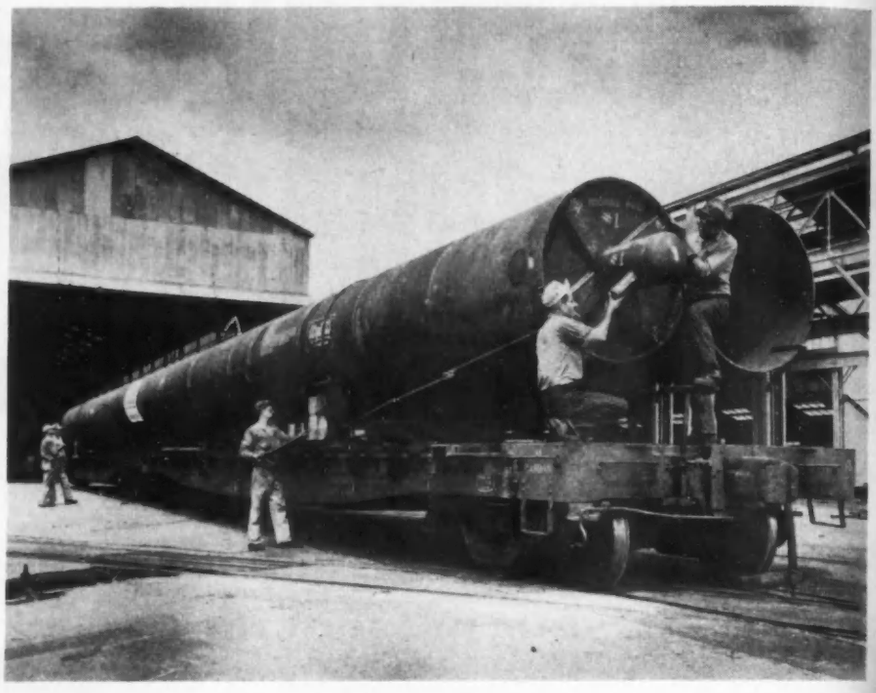
*Specify drill stem size.

AVAILABLE THROUGH YOUR SUPPLY STORE

OKEH Products are Manufactured by

TEXAS RUBBER & SPECIALTY CORP.

P. O. BOX 7368 HOUSTON, TEXAS



Mooring Posts for Lake Maracaibo Terminal

Mooring posts from high tensile steel were fabricated in the Houston plant of Wyatt Metal & Boiler Works as part of the expansion of San Lorenzo terminal of Compania Shell de Venezuela, Lake Maracaibo. The facilities were designed and constructed by Brown & Root S. A. of Venezuela and will be used by San Jacinto Venezolano, C. A., subsidiary of San Jacinto Petroleum Corporation.

Engineering Unit Created By Hughes Tool Company

Hughes Tool Company, Houston, has announced a newly created Product Observation Division within the Product Engineering Department.

In this new unit, it is planned that the Product Division's regional engineers will devote their time primarily to observing the performance of new or redesigned products in the field. Their reports and recommendations, based on on-the-spot observations, will not only be helpful in evaluating results, but will materially shorten the time required to get new products into production for general use.

R. R. Aulick, who for the past several years has directed the activities of the sales engineers in the Northern Region will head the new division as manager and will make his headquarters in Houston.

R. R. Aulick

The initial assignments to the new Product Observation Division included the following regional field engineers: W. A. Kistler, Jr., to Midland, Texas; A. G. Rollow to Oklahoma City, Okla.; R. D. Jones to Wichita Falls, Texas; R. O. Bredthauer to Houma, La. and Joseph A. Klossel, Jr., to Farmington, N. M. Also operating within the division will be a group of engineers who will be sent out from Houston on special assignments connected with product development.

Five Reed Executives Get New Assignments

Reed Roller Bit Company, Houston, recently announced new appointments for five top level executives. J. A. Grundy, formerly vice president, manufacturing, has been appointed Operating Vice President of the company. In his new position Grundy will direct all Reed operations exclusive of sales and finance. Vice President Wiley B. Noble, formerly head of engineering, is now in a new executive liaison post. He will carry out sales engineering liaison activity between Reed's general and sales management and Reed licensees and customers. G. J. Gilbert has been appointed chief engineer for the company. Formerly he was assistant chief engineer. R. G. Stockton, formerly purchasing agent, is now materials manager. He will be responsible for purchasing, production control, material control, stores and shipping in the Reed plant in Houston. Former Chief Industrial Engineer T. B. Ellis has been promoted to the position of factory manager.

Harco Celebrates Anniversary Moves to New Location

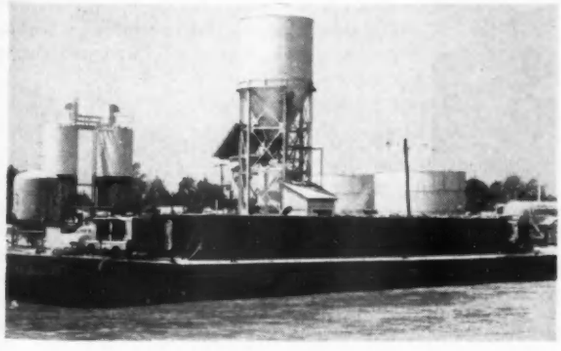
The Harco Corporation, designers of cathodic corrosion protection systems for industry, are now occupying their new headquarters in Cleveland, Ohio.

The combined executive offices and manufacturing facilities are more than five times those formerly occupied by the company and includes shipping docks and a railroad siding.

Geotechnical Corporation Now Occupying New Quarters

The Geotechnical Corporation recently moved its entire operations into a newly constructed 40,000-square-foot plant at Garland, Texas, just north of Dallas.

WE HELP ALL KINDS OF OIL MEN



The men who supply the rig, the men who service it, the men who keep it running are all oil men. They are all in the same business, and they are all a necessary part of it. The Oil and Gas Department at The National Bank of Commerce of Houston has the experience and the know-how to help each kind of oil man.

The Commerce can help you because it knows what it's talking about, and, even more important from your point of view, it knows what *you're* talking about. If you are planning to drill, if you are planning to extend needed services, if you are in the oil business, you'll find that The National Bank of Commerce will help you all the way.

E. O. Buck, *senior vice president, Oil and Gas Department.*

THE NATIONAL BANK OF

COMMERCE

OF HOUSTON

Facilities of the Oil and Gas Department of The National Bank of Commerce of Houston are available in Wyoming, Nebraska, Colorado, New Mexico, Louisiana, Mississippi, and Texas.

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what's Happening

among INDUSTRY ASSOCIATIONS

NOMADS Committee for 1959 IPE Complete Final Plans

Plans for handling the largest contingent of international delegates ever expected to attend the International Petroleum Exposition in Tulsa May 14-23, 1959, were perfected by members of the NOMADS committee representing all chapters during the API meeting in Chicago. Members of the committee representing Tulsa, New York, Dallas-Fort Worth, Houston and Los Angeles chapters are as follows: Seated L. to R., M. F. Delano, S. R. Stokvis & Sons, New York; Henry W. Pullman, Baker Oil Tools, Los Angeles; R. K. Frankl'n, Rolo Manufacturing Co., Houston; and Don Collins, Republic Supply Co., Tulsa, chairman. Standing, Harry E. Estes, Oil Well Survey Inst., Houston; Ted W. Mayborn, Drilling Magazine, Dallas; E. E. Andreson, Andreson-Lundberg Corp., New York and Bill Davidson, W. C. Norris Manufacturing Co., Tulsa. Collins, chairman of the committee, stated that early indications are that approximately 2000 oil men from countries other than U.S. and Canada will attend the I.P.E.

LA NOMADS Host International Visitors at November Meeting

Guest speaker and international guests who were present at the November meeting of the Los Angeles Chapter of NOMADS are, left to right (standing): J. L. Mathieu of Schlumberger Overseas from France; A. Cendre of A. C. M. from France; Al Dysart of International Brown from Turkey; Ray Conger of International Brown going to Guatemala; L. E. Miles of Santa Fe Drilling from Iran; Khalil Khalili of Iran Oil Company from Iran; John Schauweker of Santa Fe Drilling awaiting assignment; Leon Duane of Petro Mara from Venezuela; W. H. (Buck) May of Santa Fe Drilling going to Guatemala. (Seated) Arthur R. Little of D & E from Nigeria; Bill Lance of Santa Fe Drilling from Burma; A. E. Patterson of the Los Angeles Dodgers, speaker; Vernon E. Clayton of I.P.C. from Iraq.

PES of Libya Named Latest SEG Affiliate

The Petroleum Exploration Society of Libya, whose objects are the increase and diffusion of geological knowledge and the promotion of fellowship and cooperation among geologists, geophysicists, paleontologists, petroleum engineers and all those interested in petroleum, minerals and water exploration, is the most recent among the growing family of world technical societies to affiliate with the Society of Exploration Geophysicists. This was announced recently by Robert Dyk, secretary-treasurer of SEG, and chief geophysicist for Tidewater Oil Co., San Francisco.

President of the Tripoli-based society is Donald M. West, Mobil Oil of Canada, Ltd. The other officers are J. Allen Sawyer, Esso Standard (Libya) Inc., vice president; Jacques Canaple, Compagnie des Petroles Total (Libya), vice president; Daniel K. Hamilton, American Overseas Petroleum Ltd., secretary; Alex Stoupnitsky, Compagnie Generale de Geophysique, treasurer; Sam B. Frazier, Gulf Oil Company of Libya, director; and Ronald C. MacLean, D'Arcy Exploration Co. (Africa) Ltd., director.

Duly recognized as a technical society by the Nazir of Interior, Province of Tripolitania, the new society holds regular monthly meetings at the Uaddan Hotel in Tripoli with an attendance of over a hundred oil exploration scientists. More frequent meetings are being planned, according to West, and visiting exploration men will be welcome.

Offshore Lectures Co-Sponsored by AAODC

The American Association of Oilwell Drilling Contractors joined with the Tulane University School of Law as co-sponsors of the third symposium on "Legal Problems in the Tidelands," which was held on Friday and Saturday, November 21 and 22 in the St. Charles Hotel in downtown New Orleans, La. The first symposium of the series was held in the fall of 1956.

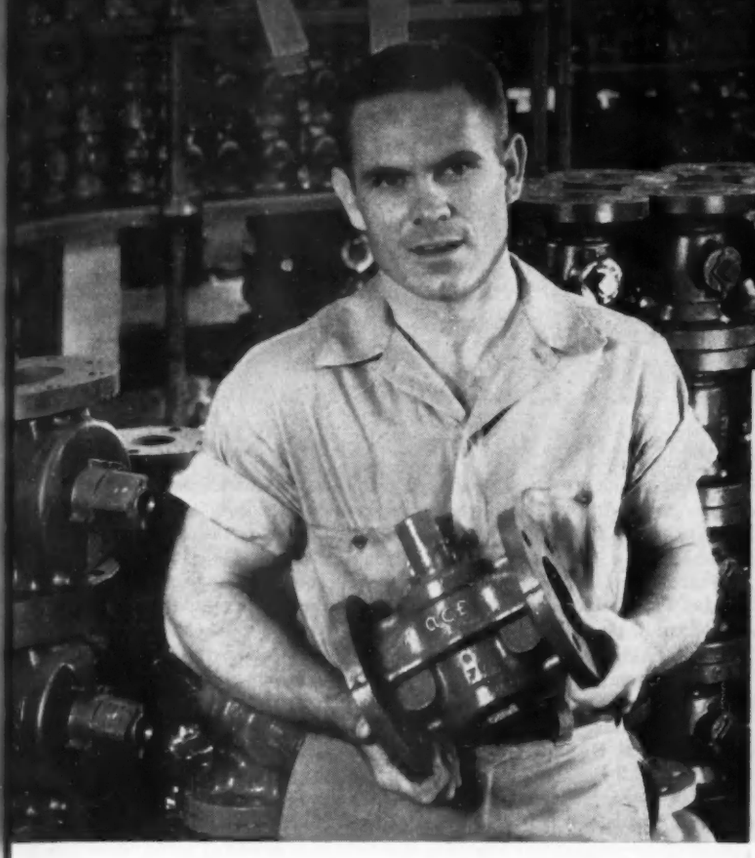
The program featured congressional studies of offshore oil operations, the federal-state interim agreement, federal and state laws on leasing, drilling and production, personal injury procedures, liability insurance for miscellaneous vessels, international law developments, Latin American laws and recent developments affecting offshore operations.

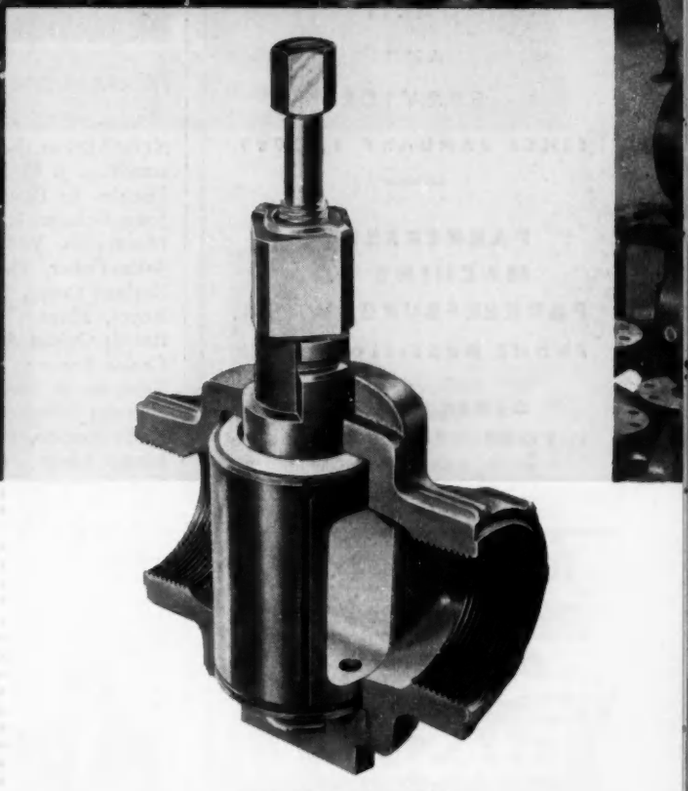
IPAA Will Establish California Headquarters

Alan White, Assistant director of information for the Independent Petroleum Association of America, will establish a headquarters in California as part of a one-year pilot project approved by the IPAA executive committee. A definite location has not as yet been determined.

White will work with the West Coast members, primarily to develop ways and means to implement local-level information programs. The IPAA has indicated, if successful, the plans of sending IPAA staff members into different areas may be adopted permanently.

ACF Lubricated Plug Valves





The most versatile valve your supplier has on hand

The ACF Lubricated Plug Valve demonstrates its versatility by operating efficiently and economically in a wide range of service applications: in chemical plants, sewage and water works, paper mills, oil field production, refining, mining operations, coke plants —it's a long list.

The valve can be installed in any position and it fits into the smallest possible space. It can be serviced quickly and requires minimum attention. It operates easily with a quarter-turn. It is safe against rupture. Due to its efficient lubrication system, corrosion is reduced to a minimum.

Both rectangular and round port valves have full pipe area openings: provide through-conduit flow with minimum turbulence, and minimum pressure drop.

. . . And W-K-M's creative engineering assures standards of design, dependability, and economy that meet your own engineering criteria.

a product of
W-K-M's
Creative Engineering

Semi-steel • Ni-resist
Carbon Steel
Bronze • Aluminum
Multiport • Round Port Opening
Steam Jacketed Base Plate
Venturi
V-Port and Diamond Port
Proportioning • Throttling

Write for Catalog 400

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ORDER THROUGH
YOUR SUPPLY STORE

for **leakproof, pressure-tight connections**

use **TiteSeal®**

SEALING COMPOUNDS

Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.

7 BASIC BLENDS

LIQUID WRENCH®

The super-penetrating rust solvent

LOOSENS

rusted bolts, nuts, screws, 'frozen' parts

Liquid Wrench works *fast*...yet is absolutely safe for all metals and alloys.

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At Industrial, Automotive, Hardware, Plumbing Jobbers

RADIATOR SPECIALTY CO.
Charlotte, North Carolina

SOLDER SEAL PRODUCTS

International Visitors Guests of Houston NOMADS at Dinner

Some 29 international NOMAD members were dinner guests of the Houston chapter of NOMADS at their November dinner meeting. The international visitors are, left to right, standing: J. C. Robbins, Iran Oil Co., Teheran, Iran; Oscar Gonzalez Ugaz, Impresa Fiscales de Peru, Lima, Peru; Jim Daive (rear), Iraq Petroleum Co., Baghdad, Iraq; John Hobson, Iraq Petroleum Co., Baghdad; Mark Glover (rear), Cameron Iron Works, Maracaibo, Venezuela; R. E. Bates, Baroid Division, National Lead Co., Maracaibo; John Fuller, Planet Exploration Co., Sydney, Australia; P. W. Cooke, Magnet-Cove-Barium Corp., London, England; J. Rastagar, National Iranian Oil Co., Teheran; R. Reyes, Hughes Tool Company, Mexico City; Raydivaldo Ribeiro, Petrobras, Bahia, Brazil; Orisan Almeida, Petrobras, Bahia, Brazil; Carlos Alvez, Petrobras, Bahia, Brazil; Carlos Periera, Petrobras, Bahia, Brazil. Seated: M. Hessabi, National Iranian Oil Co., Teheran; B. Naderi, National Iranian Oil Co., Teheran; J. Lahrrere, C.F.P.A., Algiers Algeria; Maurice Escole, C.F.P.A., Algiers; Padilha de Luz, Petrobras, Bahia, Brazil; Helio Rosado, Petrobras, Bahia, Brazil; Jean Frayssinet, Iraq Petroleum Co., Baghdad; Eladio Lima, Petrobras, Bahia, Brazil; Bob Lingwood, Iraq Petroleum Co., Baghdad. Not shown: Brinton McKeown, Kuwait Oil Co., Kuwait; C. Calamasi, Gulf Oil Co. of Sicily, Palermo, Sicily; L. Chunn, Gulf Oil Co. of Sicily, Palermo; Frank Allaire, Cameron Iron Works, Buenos Aires, Argentina; C. Montiero, Petrobras, Bahia, Brazil; R. E. Souther, Baroid Division, National Lead Co., Caracas.

Out-of-Town Guests Visit New York NOMADS

The New York NOMADS held its usual November party in the Palm Terrace of the Hotel Roosevelt with a large group of NOMADS and guests in attendance. The out-of-town guests who were present are, seated left to right: C. A. Don, Schlumberger Well Surveying Corp.; B. Beverly, Arabian American Oil Co.; W. G. Clark, Standard-Vacuum Oil Co.; J. R. Stubbins, Oficina Tecnica Stubbins, C. A. Caracas, Venezuela; P. Swales, Sui Gas Transmission Co., Ltd., Karachi; J. J. Rice, Drilling & Exploration Co., Brazil; Geraldo O. Penna, Chicago Bridge & Iron Co., Brazil. Standing left to right: C. M. King, Baker Oil Tools; G. H. Ratcliffe, Shell Co. de Venezuela; S. Baker, Cameron Iron Works; R. Gaylord, Wagner Morehouse, Inc., Los Angeles, Calif.; J. W. Boswell, Boswell International, Tokyo, Japan, J. C. Robbins, Iran Oil Co.

Five Denver Ex-Chairmen of Oil AIME Honored

Certificates of appreciation were presented to five past chairmen of the Denver section of the Society of Petroleum Engineers of AIME. The presentation, in the name of the board of directors, was made at the first fall meeting in September.

J. D. Harris, Core Laboratories, Denver section chairman, presented the framed, hand-lettered service mementoes to Robert S. Cooke, Union Oil of California; T. O. H. Mattson, The Texas Co.; Robert L. Hoss, Vaughey & Vaughey; and Marvin F. Owens, Central Bank and Trust. The fifth receipient, Paul Grim, The Texas Co., was honored in absentia.

Out of this *complete* line of new and modern packers you can fulfill any production need from simple single-zone installations through the increasingly popular and profitable multiple-completions to efficient water-flood applications.

Regardless of depth, pressure differentials, temperatures or other well conditions, one (or a combination) of these Baker Packers is exactly "tailored" to your well requirements. Baker offers the complete line, both retrievable and drillable types—with a choice of setting methods—to satisfy any surface or sub-surface condition.

Turn to Page 492 of your new BAKER (or Composite) Catalog for the 46-page section containing complete descriptions, applications and specifications on all Baker Packers.

BAKER RETRIEVABLE PRODUCTION PACKERS

MULTIPLE-ZONE | *SINGLE ZONE AND WATER FLOODING*

BAKER MODEL "G" PARALLEL PACKERS

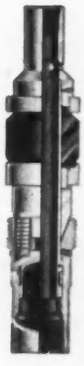
Single-Grip PRODUCT NO. 740-G
Double-Grip PRODUCT NO. 741-G

The ideal retrievable upper packer for two-packer, parallel string dual-zone installations. Embodies full-opening, long string through lower packer with separately retrievable short string that can be anchored to upper packer if desired. Double-Grip version is identical to Single-Grip, but in addition contains hydraulically actuated, button-type hold-down.

BAKER MODELS "MOA" AND "MOB" CROSS-OVER SNAP-SET PACKERS

PRODUCT NOS. 636-MOA AND 636-MOB

Used as the upper retrievable packer in single-string two-packer, selective cross-over tubing and annulus dual-zone production hook-ups. Set with set-down weight. Released and recocked for repeat setting by picking up on tubing. Also available with hydraulically actuated button-type hold-down.



BAKER DUAL PUMPING PACKER

PRODUCT NO. 694

Used as the upper retrievable packer in two-packer pumping hook-ups involving dual-zone pump. Set and released in same manner as Cross-over Snap Set packers above.

BAKER MODEL "E" RETRIEVABLE CASING PACKER

PRODUCT NO. 420-E

One of the shortest, most compact, set down retrievable packers available. Ideal for light or medium duty production requirements, or for all-around water flooding use. Simple J-Slot setting mechanism. Also available with hydraulically actuated button-type hold-down.

BAKER MODEL "A" RETRIEVABLE TENSION PACKER

PRODUCT NO. 739-A

One of the shortest, most modern high-performance tension packers. Ideal for economical low- or high-pressure water flooding. Rugged enough for many high-pressure fracturing and acidizing operations. Simple J-Slot setting mechanism.

BAKER
OIL TOOLS, INC.
HOUSTON
LOS ANGELES
NEW YORK

The

Producers Supply & Tool Co.

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Oil & Gas Well Supplies

45 Years in the Oil Well Supply Business

40 Years with stores in Texas

Everything for the drilling, producing and pipeline industry

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SALES OFFICES

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Corpus Christi, Texas
Graham, Texas
Houston, Texas
Kamay, Texas
Olney, Texas
Snyder, Texas
Wichita Falls, Texas

PIPE YARDS

Corpus Christi, Texas
Houston, Texas
Lone Star, Texas
Pueblo, Colo.

SQUEAKS from the BULLWHEEL

Currency Flame

Junior: "How can I introduce myself to a girl whose hobby is collecting foreign coins?"

Senior: "Tell her you have a yen for her."

Catch as Catch Can

First girl: "I caught my boy friend necking."

Second girl: "That's the way I caught mine, too."

Too Strict

Two dogs were having a chat one day and one of them noticed the other was feeling awfully low. So he said to his friend, "Why don't you go see a psychiatrist?" To which the other dog replied, "You know I'm not allowed on the couch."

Correct!

The only person less popular than a wise guy is a wise guy who's right.

Scrambled Economics

Girls without principle draw considerable interest.

WORLD OIL

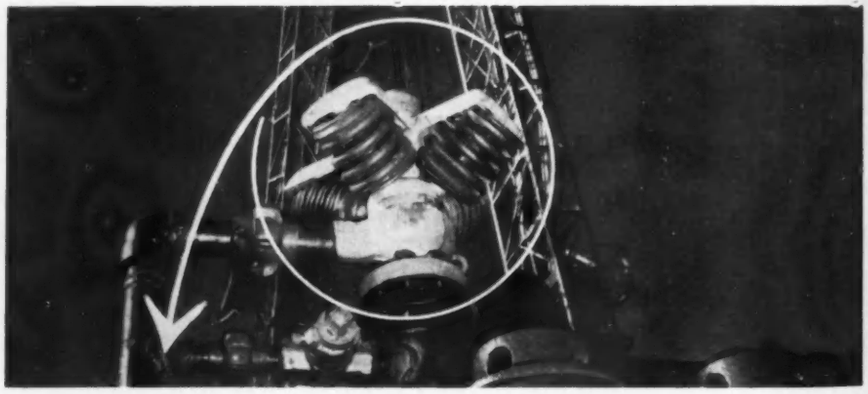
"No oil; just barrels!
Two hundred a day."

Rich Relative

The kin we love to touch.

Friendly Relations

And then there was the one about the dumb blonde who thought the universal joint is a bar in the United Nations building.



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Operate rig circulation systems for maximum effectiveness — in complete safety — with Kinzbach Model 112 Mud Pump Relief Valves installed. You are assured instantaneous relief at set pressure with quick, automatic reset to maintain flow and pressure in partially blocked systems. When system is completely blocked, Kinzbach Pressure Relief Valves give full bypass for safety to pumps and other equipment.

Kinzbach Model 112 Pressure Relief Valve pressure range from 500 psi to 16,500 psi safely meets all drilling requirements including cementing and fracturing jobs. Available in 2" and 3" sizes. Write for complete catalog or see your Composite Catalog.

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Powerful M-3's Perforate Deep Well for 1296 B/D

McCullough M-3 Bullet Guns Get Production After Jets of Another Make Fail

This deep well in New Mexico had previously been jet perforated by another service company without results.

Producing formation was a 26′ zone between 11,977′ and 12,003′. 5½″ OD 20 lb. casing had been cemented through the zone.

McCullough was called to reperforate the well with M-3 Bullet Perforators. 156 improved ½″ Ogival Bullets, six per foot, were fired in the 26′ interval.

Resulting production was 1296 barrels of oil per day. Operator was very pleased with the good results of the job.

McCullough M-3 Bullet Guns are made to shoot harder—to obtain deepest penetration under severe well conditions. M-3 Guns will get production or increase production even after others have failed.

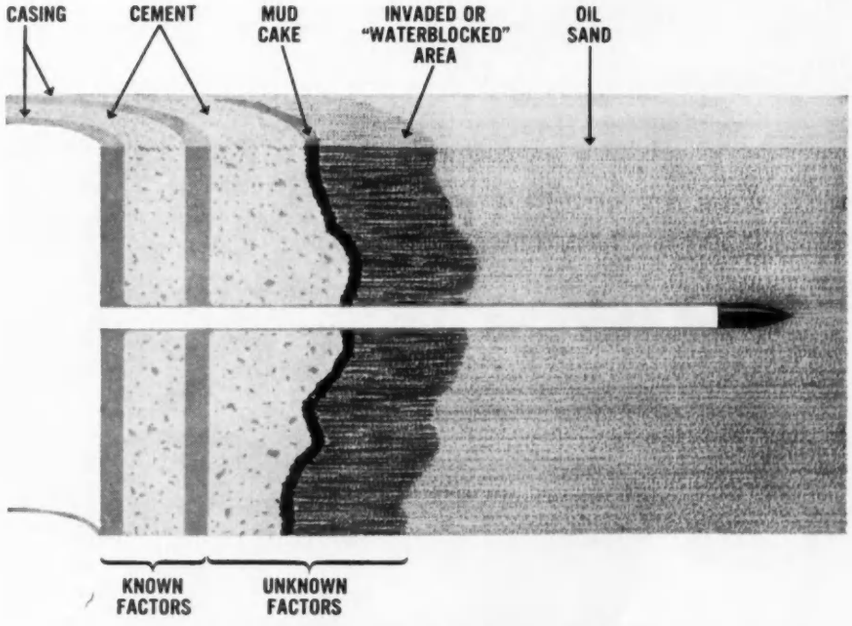
The job shown above is certified to be a true field report of service rendered.

For full information on the McCullough M-3 Bullet Perforator, write to:

McCullough Tool Company

5820 South Alameda

Los Angeles 58, Calif.



HARDEST SHOOTING M-3 BULLET GUNS
"PUT THE SHOTS WHERE THEY COUNT"—DEEP IN THE OIL ZONE

M-3 Guns are designed to obtain the deepest possible penetration. They have the extra firing power necessary to pierce the known thickness of multiple casing strings with cement in the annulus—to penetrate through an unknown thickness of cement outside the casing—to get through the variable depth of a mud cake and "water blocked" area—to penetrate deep out into the virgin oil zone.

Because they shoot harder, McCullough M-3 Guns get the results you want—better production—more oil! Size for size, M-3's consistently outshoot all other makes of bullet guns.

McCullough® TOOL COMPANY

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For more data on advertised products, use Readers' Service Cards, last page.

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WARN MANUFACTURING CO., Inc. Riverton Box 6064-WO1, Seattle 88, Wash.

Tall Tale

It was 9 a.m. when the TV producer came rolling in to face his irate wife.

"It's very simple," he explained, "the rehearsals lasted until midnight. Then I drove one of the chorus girls home, and she asked me in for a drink. We had three or four, and by that time it was so late she suggested I spend the night with her. So I did.'

"A likely story," said his wife. "You've been out playing poker with the boys again."

Oust the King

The Maharajah of an interior Indian province decreed that no wild animals could be killed. Soon the country was overrun by man eating tigers, lions, panthers and boars. The people stood it just so long, and, finally, gave the Maharajah the heave-ho. It was one of the few cases in history where the reign was called on account of game.

Be Kind to Animals

A young four-year-old was stroking his cat before the fire when the cat began to purr loudly. His mother looked up from her sewing to see the youngster pulling the cat away from the fire by the tail.

"Don't abuse the poor kitty," admonished the mother.

"I'm not," said the youngster. "I'm just getting him away from the fire before he boils over."

The Most

The scene was a teenage rock n' roll juke joint. The waiter dropped a tray full of dishes and six couples got up to dance.

For Health's Sake

The new commander, inspecting the camp's water supply, asked what was being done about contamination.

"Well, sir," said the non-com, "we boil it first."

"Fine," nodded the general.

"Then we filter it," said the sergeant and the general nodded approvingly. "And then," continued the sergeant, "just to play safe, we drink beer."

Self Defense

"Mommy," said the little boy, "I was in a fight today."

"What happened son?"

"Some boy called me a sissy."

"What did you do son?"

"I hit him with my purse."

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Security

A tourist stopped where a farmer was erecting a building. "What are you building?" he asked.

"Wal," answered the farmer, "if I can rent it, it's a rustic cottage, and if I can't, it's a cow shed."

Gobbledygook

An admirer came up to a senatorial candidate after his speech and said: "Congratulations. That was a fine speech. I like the straight-forward way you dodged those issues."

Souvenirs

A man took his Great Dane to a vet. "Doctor," he said, "you've got to do something. My dog does nothing but chase sports cars."

"Well, that's only natural," replied the vet. "Most dogs chase cars."

"Yes," the man agreed. "But mine catches them and buries them in the back yard."

Quick Settlement

"Sorry, old man, that my hen got loose and scratched up your garden."

"Oh, that's all right. My dog ate your hen."

"Fine—I just ran over your dog."

Disrespectful

A sales manager had one of his salesmen on the carpet. The young salesman resented the call-down and, becoming quite huffy, said: "Don't talk to me that way. I take orders from no man!"

"Now we're getting somewhere," said the sales manager. "That's just what I'm raising hell about."

Safety Slogan

"Watch out for school children . . . especially if they're driving cars."

Statistics

A traffic expert said recently that if all the cars in the nation were placed end to end, some fool would pull out and try to pass 'em.

Horse Power

The lady was having difficulty trying to board the train with a horse.

"Are you out of your mind, lady?" exploded the conductor.

"I can't help it," the woman replied, pushing her horse up the steps of the Pullman, "he gets sick on the buses."

Cold War

Nations flexing their missiles.

Simple Deduction

A snobbish rich man drove up to the front of a hotel, in a Ford Thunderbird. The doorman gave him a parking check for the car and got in to drive it away.

"Do you know how to handle these high powered cars?" the snob snapped.

"Yass, sir," he grinned. "I sho do—it's just a little ole Fode."

Recession Blues

"I need a job, Senator," said the man from his home state.

"There aren't any jobs," said the Senator and then thought for a moment. "But I tell you what I'll do. I'll get up a committee to investigate why there aren't any jobs and you can be he head of that for $10,000 a year."

Defense

A fellow who came into a dental office for a tooth extraction was so frightened at the prospect that the dentist sympathetically offered him a shot of whiskey. Then the fellow asked for another shot and gulped it down. The dentist then asked kindly: "There, young fellow. Do you feel any braver?" Got your courage back?"

"Yeah," snarled the man, "and brother, I'd like to see anybody touch my teeth."

Association

"You think so much of your old golf game that you don't even remember when we were married."

"Of course I do. That was the day I sank that 40-foot putt."

Basic Psychology

An attractive woman psychiatrist attended a convention. At one lecture the man sitting next to her began to pinch her. Annoyed, she was about to give him an angry retort when she changed her mind.

"Why should I get angry?" she decided. "After all, it's his problem."

That's the Breaks

At a Communist gathering one of the comrades stood up suddenly and addressed the chairman with a worried look on his face.

"Comrade," he said, "There's just one thing I want to know. What happens to my unemployment checks when we overthrow the capitalist government?"

BRITISH MADE H-E 300 P.A. TRACTOR DRILLMASTER

MULTI-PURPOSE · HIGHLY MOBILE

The Hands-England Drillmaster 300 P.A. Rotary Drill is now available mounted on a Fordson Major Tractor and is illustrated on left.

This design provides great manoeuvrability and is intended primarily to enable the well known H-E Drillmaster 300 P.A. Rotary Drill to be used for Quarry and Open Cast blast or shot holes.

Although the H-E Drillmaster 300 P.A. mounted on a diesel engined tractor, is ideal for Quarry and Open Cast operations, it is equally applicable to some difficult "off the road" locations, such as may be encountered during seismic exploration particularly in highly cultivated areas.

An air compressor giving 99 C F M can be mounted directly onto the drill subframe and driven from the tractor engine. This compressor gives an up-hole annular velocity of 3,000 ft./min. when using flush jointed drill pipe and holes of the following sizes:

1⅝" o/d. Drill Pipe	2⅞" dia. hole	
1.29/32" "	"	3⅛" " "
2⅜" "	"	" 3⅜" " "
2⅞" "	"	" 3¾" " "

Larger holes or holes drilled with mud circulation can of course be drilled, but the equipment for these operations must be mounted on a separate trailer or tractor.

The H-E Tractor Drillmaster will be found to cover the majority of drilling requirements of the Quarry and Open Cast operator, the Geologist, the Mineralogist, and the Geophysicist.

Write for illustrated folders giving full details and specifications of this equipment.

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New Books, Maps and Movies

(More book reviews on Page 268)

RESEARCH STUDY OF SHUT-IN GAS WELLS IN TEXAS RAILROAD COMMISSION DISTRICTS 1, 2, 3 & 4, Austin Oil and Gas Publishing Co., Post Office Box 5146, West Austin Station, Austin, Texas, $80.

The data for this report were compiled and prepared from the records of the Railroad Commission of Texas. Material was assembled from some 25,000 ledger sheets, standardized and indexed as reported through Dec. 31, 1957. Approximately 3,000 shut-in gas wells are listed.

This report sets out in a clear, concise and readily accessible manner the following information: railroad commission district — county — field — operator — lease — well number — survey — date of completion — perforation interval — formation or reservoir tops — pressures — gravity of gas — potential test.

THE SEARCH FOR AND EXPLOITATION OF CRUDE OIL AND NATURAL GAS IN OEEC ZONE, OEEC Publications Office, 1346 Connecticut Avenue, N W, Suite 1223, Washington 6, D. C., $12.

A multicolored geological map of western Europe, showing in detail the attitude of sedimentary beds classified according to the likelihood of their containing oil, oil and gas fields and their principal structures, are shown in an 80-page report. Also included are marine contours, indicating depths to 200 meters.

Also, the map is accompanied by a geological report on Europe, a review of various aspects of the search for and exploitation of hydrocarbons and a comparative summary of the relevant fiscal and mining laws applied in the different countries. The map is in five colors, 195 cm by 115 cm in three overlapping sections. It comes packed in a cardboard cylinder with the report.

DESERT ENTERPRISE, Harvard University Press, Cambridge, Mass., by David H. Finnie, $5.

A most timely subject, the oilman from the West and the Arab of the Middle East, is analyzed in this book. Problems of a cultural nature plus the inherent wariness of the two peoples conflict and present a challenge to the oil companies.

The oil industry has brought social and economic advancement, but often the advantages antagonize by raising the level of aspiration above the level of immediate attainment.

Finnie, a lawyer, wrote this book as an independent observer of the Middle Eastern scene.

PETROLEUM REVIEW, PECOS COUNTY, TEXAS, Phifer Petroleum Publications, Houston 25, P.O. Box 20,024, $20.

This is No. 12 in the series of books that outlines the discovery, development and production in 14 counties of West Texas and New Mexico. The new 204-page book covers the 105 fields discovered in the county since the Yates field in 1926. At the end of 1957, nearly 600 million barrels of oil had been produced during the 31 years since the first discovery.

The review was compiled by Robert L. Phifer from the records and hearing files of the Railroad Commission of Texas.

WEST TEXAS ELECTRICAL LOG SERVICE, 1407 Ross Avenue, Dallas 2.

Volume 3, the 1958 edition, contains a compilation of all electrical and radioactivity logs released to the oil industry from Jan. 28, 1957, through Jan. 27, 1958, by counties, by fields and by wildcat and development wells covering the West Texas and New Mexico area.

This catalog is to be used in conjunction with West Texas Electrical Log Service Catalog Volumes 1 and 2.

ERRATUM

Four figures were inadvertently transposed in the article "Mississippian Series Possibilities" by Sidney B. Anderson which appeared in the December, 1958, issue of WORLD OIL. Figure 4 should have been labeled Figure 5 and conversely, Figure 5 should have been numbered Figure 4. Also, Figure 6 should be relabeled Figure 7 and Figure 7 renumbered Figure 6.

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RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All classified ads payable in advance.** Send copy and checks to: Trading Post Classified Section, World Oil, P. O. Box 2608, Houston, Texas.

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SITUATIONS WANTED

■ Exploration Geologist, 33, married, family, masters, desires relocation. 8 years experience; 5 rig supervision, well completions, workovers, 3 consulting. Prefer aggressive independent or investment group, advancement opportunity. Excellent references. Experienced all phases oil business. Box 181-W, WORLD OIL, Houston, Texas.

■ Production or work over foreman three years college. 27 years experience. 16 years in secondary recovery. Box 180-W, WORLD OIL, Houston 1, Texas.

PILOT. Presently employed desires change. Age 39. Married, two children. Owns home. Airline transport rating with commercial privileges on multi & single engine land craft.
5,000 accident-free hours in DC-3's, DC-12's, 310's and Navions. 400 actual instrument hours. U.S.A.F. reserve on flight status. Some sales experience. Salary open. References & complete resume available. Box 179-W, WORLD OIL, Houston, Texas.

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Drilling Superintendent—
Petroleum Engineer

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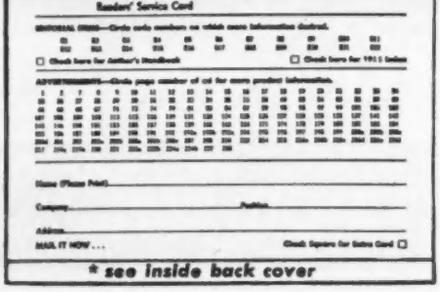
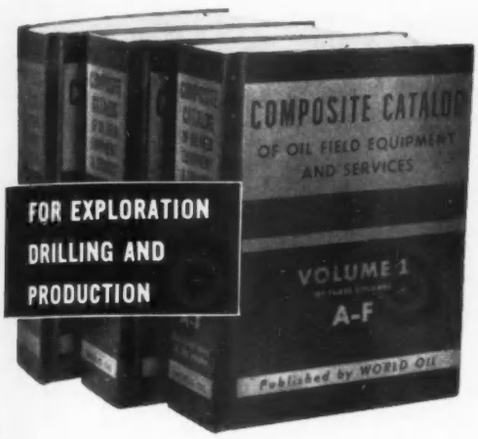


* see inside back cover

THE SPECIALIZED OIL INDUSTRIES . . .

Specialized Petroleum Industry Catalogs—If you buy for or sell to the Petroleum Industry markets, you need adequate catalog data. Here are Gulf Publishing Company's three specialized oil industry pre-filed catalogs. Like the publications pictured on the opposite page, the catalogs are symbolic of the service Gulf Publishing has provided this industry for 43 years.



For 30 years COMPOSITE CATALOG OF OIL FIELD EQUIPMENT AND SERVICES has been serving the Drilling-Production Division of the Industry.

Used all over the world, this current catalog has 5,384 pages from more than 500 different companies selling to this industry. It is indexed and cross-indexed for easy reference.

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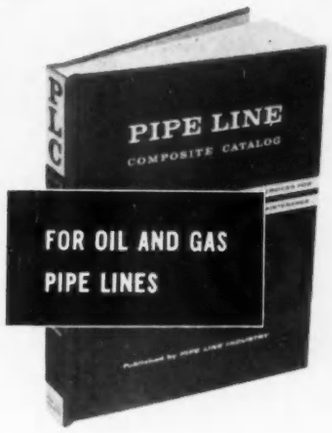

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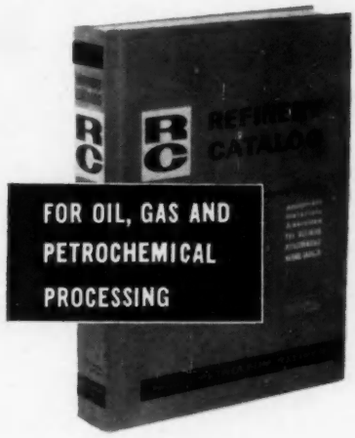

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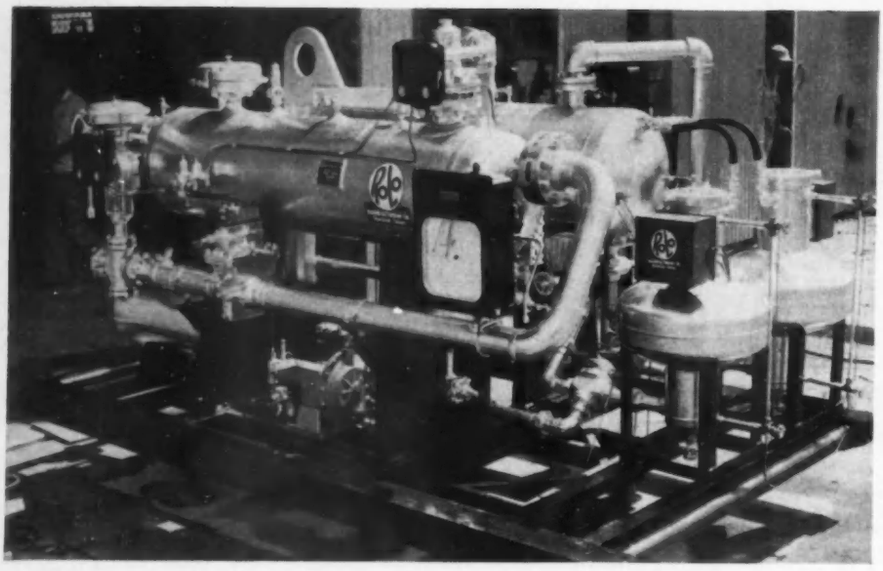


Two-Stage Test Unit

Designed and manufactured by Rolo Manufacturing Company, this skid-mounted two-stage unit separates and meters oil, water and gas. The first stage separator is 1,440 psi and the second stage is 125 psi working pressure. A methanol injection system is an integral part of the unit. The test unit, a Rolo Wellchecker, is owned by Southern Well Testing Company of Lafayette. It is available to producers on a rental basis.

(This item supplements Rolo Manufacturing Company data on Pages 4394-4399 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E1** on Readers' Service Card, last page this issue.

First B-134 Mast

S. N. MAREP (Societe Nationale de Materiel pour la Recherche et l'Exploitation du Petrole), manufacturing subsidiary of the French Oil Prospecting Companies, recently revealed the first B-134 mast built under license agreement with Continental-Emsco Company of Dallas.

Over three hundred representatives of the oil industry of France and other countries attended the showing of the portable mast. The mast was shown at S. N. MAREP's Baudet Donon Roussel plant in Blanc Misseron, France.

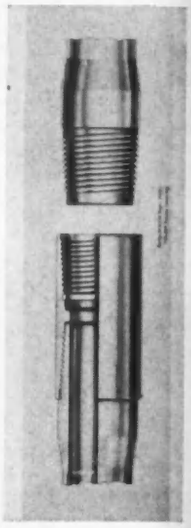
The B-134 mast is an open-faced mast with 830,000 pound nominal gross capacity. It has a clear working height of 134 feet and is capable of handling trebles in 90 foot stands.

S. N. MAREP was established in 1945 as a subsidiary of the French Oil Prospecting Companies to manufacture and supply oil field equipment in France. The French company established a license agreement with Continental-Emsco approximately a year ago and since that time has produced drilling equipment of Continental-Emsco design.

(This item supplements Continental-Emsco Company data on Pages 1365-1436 & 1437 & 1498, 23rd [1958-59] Revision.)

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

New Tubing Joints

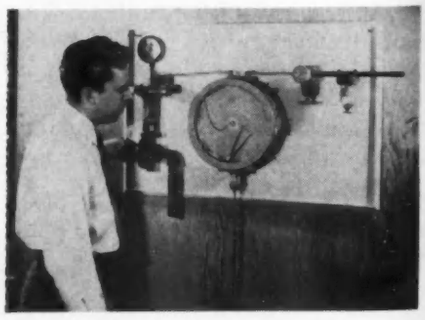


Deep well production tubing strings can now have connections with high yield strength, rugged thread forms, positive metal-to-metal thread seal plus a compressed soft seal and fast make-up of connections, all without excessive pipe upset. The joint is designed to withstand a greater amount of internal pressure than the nominal body of the tube.

The new Hardy-Griffin Engineering Corporation Dual Seal coupling joint features an especially developed thread form, a modified Trunkaded Buttress type, that is extremely rugged, that holds under all conditions of tension and makes a metal-to-metal seal on the thread shoulders, leaving the crests unengaged. The Dual Seal thread is more than 100 percent efficient, requiring low make-up torque. In the design of the Trunkaded Buttress thread Hardy-Griffin has complimented all angle changes with a radius or have stress-relieved the angle changes. There are no built-in undercuts or points where torque-loading will create points of stress connections.

(This item supplements Hardy-Griffin Engineering Corporation data on Pages 2294-2295 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E3** on Readers' Service Card, last page this issue.



Recording Controller

A pneumatic recording temperature control, designed primarily for industrial process uses, has been introduced by The Partlow Corporation.

The control, a simple mercury-actuated mechanism utilizes no electricity and is particularly well adapted for use by process industries where a precise, explosion-proof, throttling-type control is required. The control utilizes a 15-pound air line to actuate an air-operated steam valve or other air operated devices.

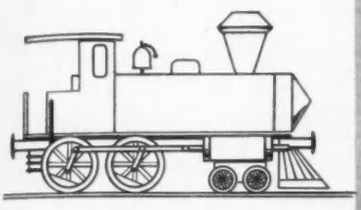
(This item supplements The Partlow Corporation data on Pages 3982-3983 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

100 Years ago

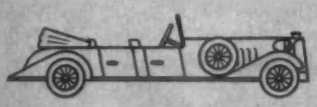
Beginning of Oil Production

40 Years ago



Mintrops Patent of Seismic Refraction Method

38 Years ago

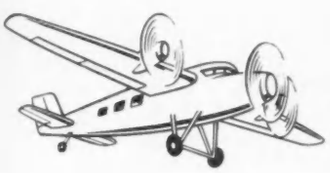


SEISMOS

G. M. B. H.

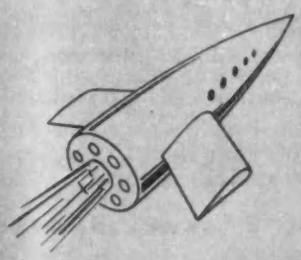
Hanover-Germany established by Ludger Mintrop

30 Years ago



first Measurement with transportable Gravity Meter by SEISMOS G. M. B. H.

3 Years ago



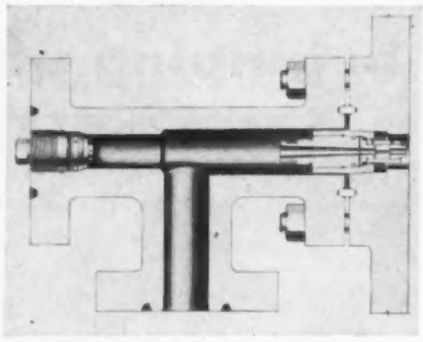
first seismic Fieldwork with Transistor Amplifiers by SEISMOS G. M. B. H.

Choke Flow Control

A new type positive choke flow control employing the patented access fitting principle has been placed on the market by Cosasco Division of Perfect Circle Corporation.

A major advantage claimed for the Cosasco flow control is that it eliminates bulky, expensive valves from oil production flow lines. There are no moving parts subjected to pressure, fluid, distortion or wear, and the choke beans can be easily changed under full operating pressure without system shutdown.

The Cosasco flow control, which replaces conventional exterior chokes, can



be used under all pressure and temperature conditions. Operating on the exclusive access fitting principle utilized by Cosasco oilfield and corrosion survey equipment, the flow control has a rated working pressure of 10,000 psi. It can be successfully used at working pressures in excess of 15,000 psi.

The flow control (see cutaway illustration) is identical in construction detail to a standard Cosasco Access Fitting, except that the gage carrier plug is replaced by a special plug that has a choke bean incorporated in its bore.

(This item supplements Cosasco Division of Perfect Circle Corporation data on Pages 1465-1468 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

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pioneers of collapsible, portable, field housing.

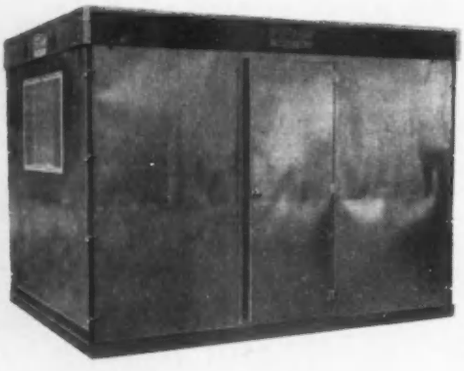
USED WORLD-WIDE.

Can be erected in 15 minutes!

Model D-1-C

Model D-1-C $585 FOB plant
Size 10′ x 10′

- **Shipping case size— 40″ x 10′ x 14″**
- **Weight—550 lbs.**
- **Also available in size 10′ x 20′, model 2D-1-C**
- **Costs less than tents— let us prove it!**



Model K-10

$995 FOB plant
Size 8′ x 10′

- **Fully insulated**
- **Join several units together**
- **Weight—950 lbs.**
- **Shipping case size— 8′ x 10′ x 15″**

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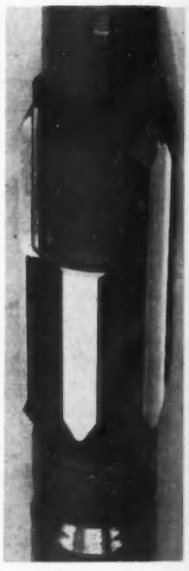
Aluminum Rib Stabilizer



Rubber sleeve type drill collar stabilizers are taking on a new look. A new development by Drilco Oil Tools, Inc., of Midland, Texas, is a rubber stabilizer with aluminum caps on the ribs.

The new stabilizer sleeve has the same steel bushing and rubber bearing as the standard rubber rib sleeves. Aluminum replaces the rubber ribs that contact the hole wall. The aluminum ribs are held to the steel bushing by a section of rubber approximately ¼-inch thick bonded to the bushing and ribs.

While drilling shale formations, rubber ribs are often cut and torn from the steel bushing. The new style aluminum rib stabilizers have given much better service in these formations. Aluminum has physical and strength properties good enough to resist the abuse the sleeve must take in normal use, but still is soft enough to be easily drilled by a wash over shoe or rock bit.

(This item supplements Drilco Oil Tools, Inc., data on Pages 1577-1581 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E6** on Readers' Service Card, last page this issue.

Needle Valve

Kerotest Manufacturing Company announces its new N-20 Globe type needle valve designed for high pressure service.

This rugged, union bonnet needle valve is for throttling, regulating or shut-off. It features a newly designed forged carbon steel body, back-seating construction which permits repacking while under pressure and heat-treated stainless steel stem operating in a sleeve yoke. The N-20 is also available in various grades of stainless steel.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

Petroleum planning

For many years, the Whitney has worked closely with the men who plan the future of petroleum.

Located in one of the nation's busiest oil centers, the Whitney is equipped and ready to handle the financing of all phases of the petroleum industry.

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* Patent No. 2,826,253

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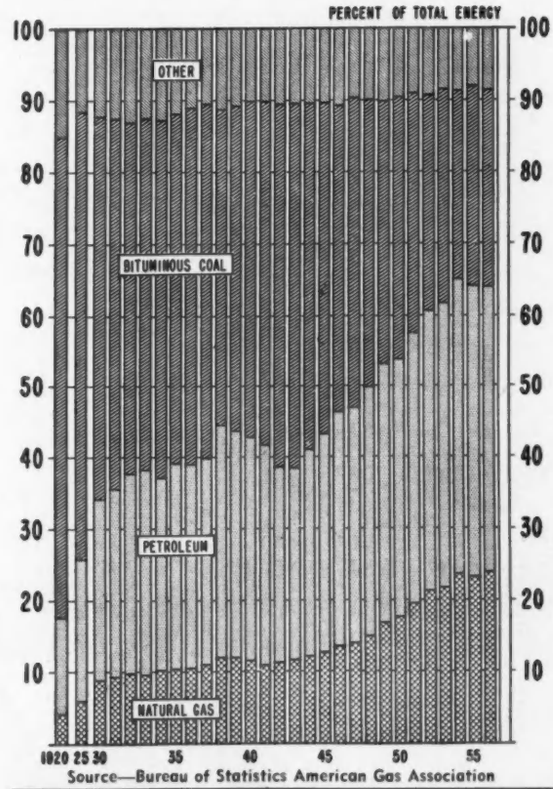
BASED ON BRITISH THERMAL UNITS



Source—Bureau of Statistics American Gas Association

WESTERN NATURAL GAS CO.

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2,000′ to 12,000′ capacity
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WICHTEX PORTABLE ROTARY RIGS
2,000′ to 5,000′ capacity

WICHTEX
MACHINERY COMPANY
P. O. Box 2250
WICHITA FALLS, TEXAS

New Seismod

Sinclair Research Laboratories, Inc., Tulsa, has developed an instrument known as the Seismod which gives an improved visual record section of seismic information without loss of character. A. C. Reid, Sinclair electronics engineer, its originator, is shown with the instrument. Seismic information is used by oil exploration specialists in the search for underground oil-bearing formations.

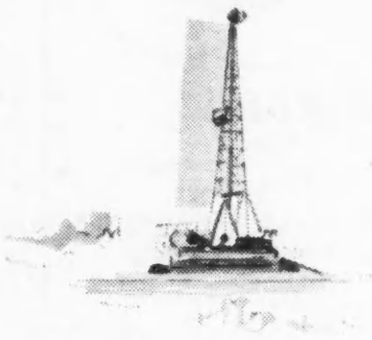
For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Bakerlok Compound

Baker Oil Tools, Inc., announces a new product, designated Bakerlok used for locking shoes and collars to prevent backing-off while drilling out. An additional advantage is prevention of damage to better grades of casing when joints are welded.

Bakerlok is furnished in a kit consisting of the compound and an activator which are mixed together and applied to the pin thread of the joint, which is then

the
SUPERIOR OIL COMPANY



OIL AND GAS BUILDING
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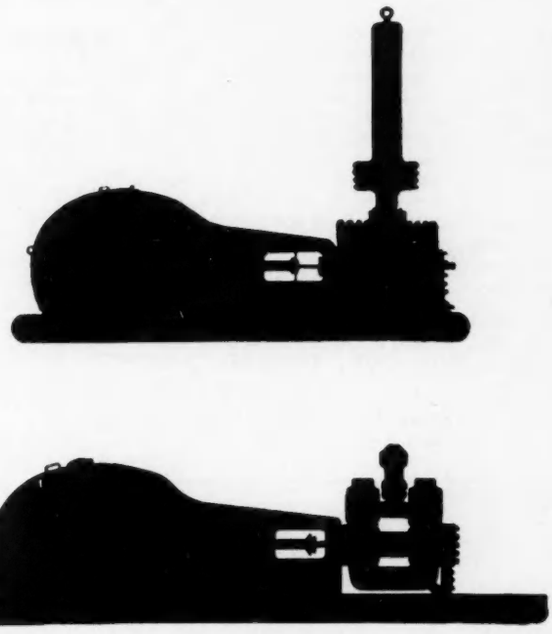
..for Shallow Drilling
D-175 and D-300

In the 175 and 300 horsepower range, these small pumps can produce the pressures and volumes to match the drilling range of all types of portable rigs . . and save on weight.

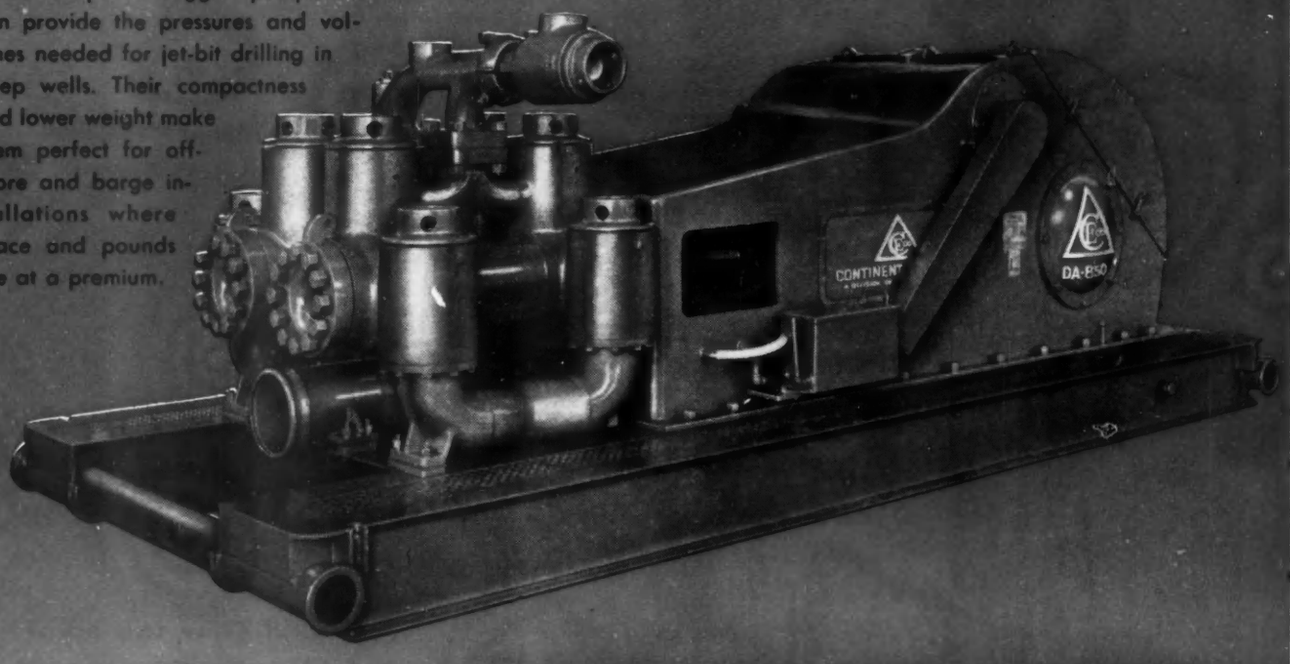
..for Medium-Deep Drilling
DA-500 and D-700

These pumps are designed for rigs in the 600 to 1100 horsepower class. Here are pumps *sized* for medium-deep drilling. They are big in capacity . . lower in weight . . yet small enough to require a minimum amount of power.



..for Deep Drilling
DA-850 and D-1000

The DA-850 at 850 hp and the D-1000 at 1000 hp are rugged pumps that can provide the pressures and volumes needed for jet-bit drilling in deep wells. Their compactness and lower weight make them perfect for offshore and barge installations where space and pounds are at a premium.



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made up and soon is firmly locked.

Torque tests have been made on 5½-inch casing joints welded with six, ¾-inch welds which brake in a torque range of from 17,000 to 20,000 foot-pounds. Clean joints locked with Bakerlok consistently broke out at substantially higher torque values, even under temperatures ranging from 50° F. to 400° F. Vibration tests, corrosion tests, and tests of the lubricating and sealing qualities all confirmed the effectiveness and all around superiority of Bakerlok.

(This item supplements Baker Oil Tools, Inc., data on Pages 417-580 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

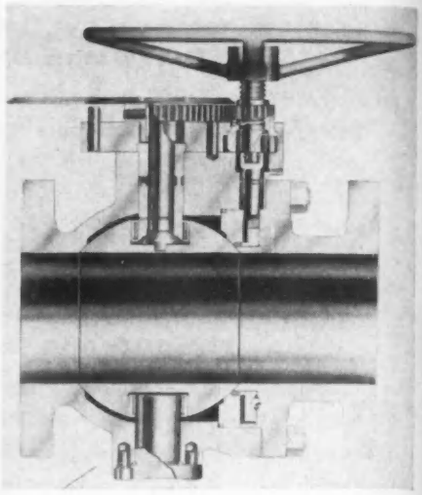
Type K Ball Plug Valves

Shown here is a cross-section view of the new Type K Ball Plug Valve recently introduced by the Hydril Company.

The new valve employs fully confined, gasket-type Teflon packing ring and new resilient stem packing to provide positive, enduring, bubble-tight seal against pressure from either direction.

The valve plug is mounted upon accurately positioned bearings for fast, easy operation. Viscous lubricants are entirely eliminated by the new valve design concept. Hydril Type K valves can be used over a wide range of service conditions, temperatures and pressures.

(This item supplements Hydril Company data on Pages 2549-2648 of the Composite Catalog, 23rd [1958-59] Revision.)



For more data, circle **No. E10** on Readers' Service Card, last page this issue.

OIL... *in Western Venezuela*

Amongst the diversity of drilling equipment in this big oil-producing area, Paxman diesels are doing a job of unfailing service driving drawworks, rotary tables and slush pumps, both up country and on offshore rigs. These engines come from a range developed from 16,000,000 hours drilling experience, known by oil men everywhere for their sound performance, rugged construction and dogged dependability. Paxman engines for all oilfield duties are built in two power ranges; 7 inch bore, 133-1,000 b.h.p. and 9.¾ inch, 533-2,300 b.h.p.

The illustration above is from a Shell photograph of one of their drilling barges on Lake Maracaibo. Four Paxman sets provide power for the slush pumps and two more Paxman engines drive alternators for power and lighting

The drawing on the left is taken from another Shell photograph of a Paxman engined Cia. Shell de Venezuela deep drilling rig at La Paz field.

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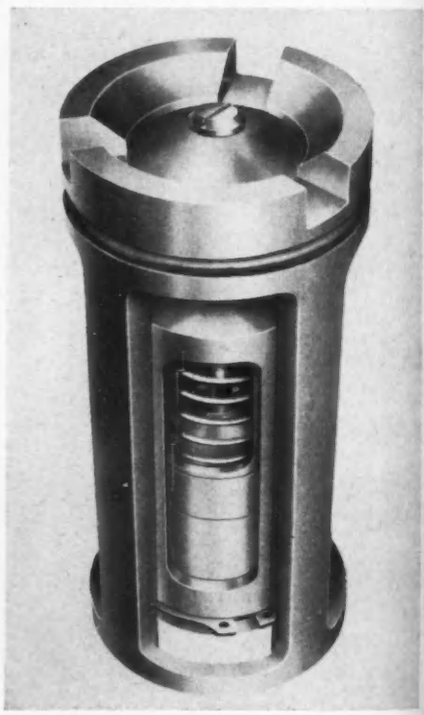
REPRESENTATIVES IN CANADA
Federal Equipment (Western) Ltd., 13120-125th Avenue, Edmonton, Alberta.

J-41



Fluid Flow Inclinometer

Sperry-Sun Well Surveying Company has announced a new type instrument for use in obtaining surface indications of hole inclination during air or gas drilling. This instrument, called the Fluid Flow Inclinometer, is positioned in the float recess directly above the bit and remains in the drill string continuously. Surface indications are obtained each time a joint of pipe is added to the drill string. Available in inclination limits of 2½°, 4°, 5½° and 7°, the FFI also serves as an effective float.

Operation of the instrument is accomplished by means of pressure acting against a spring-loaded plunger head. A plumb bob is suspended from the plunger head directly over a calibrated orifice. If hole

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Whatever your job . . . wherever you do it —you'll find Ford trucks are engineered and built to do it better! Whether you need a 4-wheel drive pickup like the one shown below—or a heavy-duty tandem similar to the one used by the Stooksberry Tank Co., you'll be *ahead* with a Ford. And for '59, there are even more reasons to invest in a Ford Heavy or Extra Heavy. You'll discover:

Greater operating economy with new, faster rear axle ratios and wider choice of transmissions.

More efficient parking brake of the internal expanding type has approximately 50% greater stopping and holding ability, requires less than half the operating effort needed for the previously used type.

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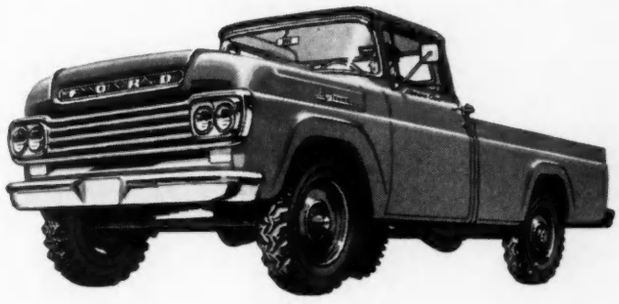
New Ford 4-wheel drive trucks available in ½- and ¾-ton pickup, stake and chassis-cab models. Ford-built at Ford's low prices. Available early 1959.



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inclination is less than the inclination limit of the FFI used, the plumb bob nose passes through the hole in the orifice and permits full passage of air or gas past the plunger head. If hole inclination exceeds the inclination limit of the instrument, the plumb bob swings over and engages a stop which holds the plunger head in a closed position, thus shutting off flow and causing an immediate pressure buildup as indicated by a surface pressure gage.

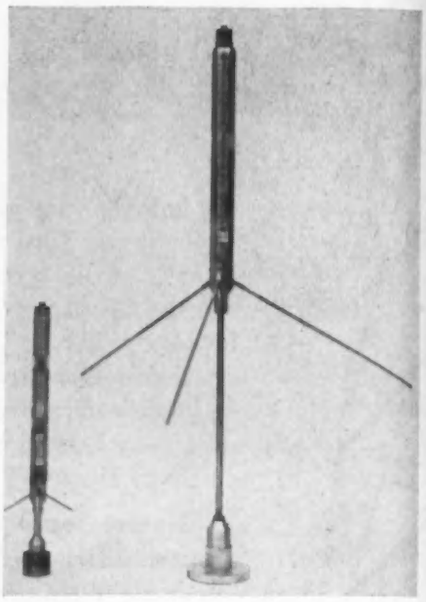
Even though hole inclination may exceed the limiting inclination of the FFI in the hole, full circulation may be regained by bleeding off the pressure and then again starting circulation to obtain normal operating pressure. The FFI is available for float recess sizes of 3½-inch Reg. and 4½-inch Reg.

(This item supplements Sperry-Sun Well Surveying Company data on Pages 4709-4714 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

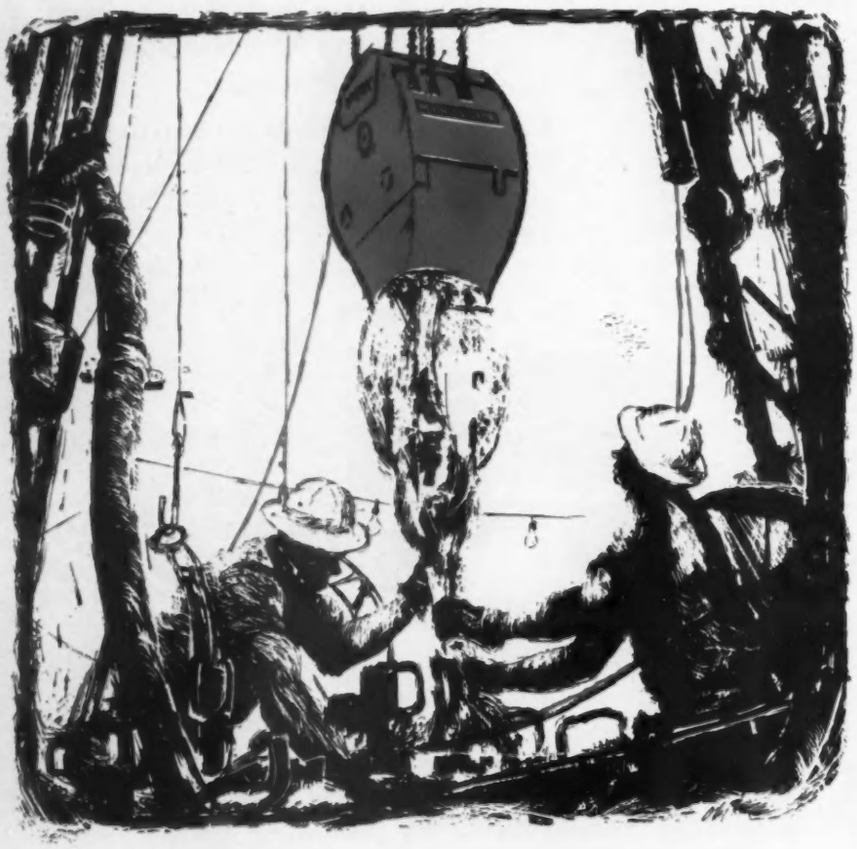
New Caliper Developed

Pictured here are the extreme sizes of calipers manufactured by Worth Well Surveys. Shown right is the 12-inch caliper and left is Worth Well Surveys' new 60-inch caliper for I.D. measurements in down-hole operations. The 5-foot caliper is an increase of 2 feet over other calipers



in the field at this time. Volume is automatically computed, as in the past, with the standard 36-inch caliper.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.



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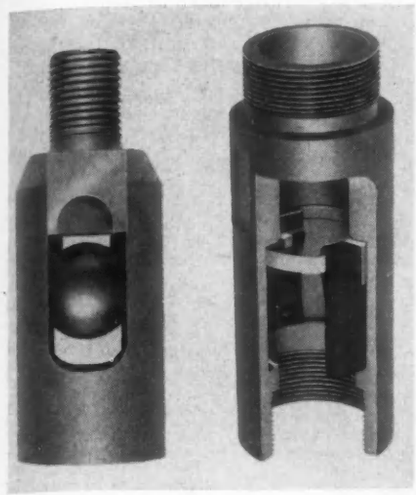
Vac-U-Matic Pump

M. L. Hart Industries is the distributor of the new Vac-U-Matic bottom hole pump designed for handling large volumes of fluid and especially recommended in water-flood operations.

The pump is designed for handling both oil and water, is a full insert pump, and when used with conventional jack and rod string maintains a constant tension at the bottom of the rod string, preventing rod buckling and permitting up to 50 percent more spm than with any other plunger type pump.

The pump utilizes common steel cables as a pumping string.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.



Rubber Guide Cage

An improvement in the Martin Rubber Guide Cage, which provides complete protection for the cage in situations where extreme or unusual ball impact might occur, has been announced by the manufacturer.

This protection is accomplished in all open cages by leaving a cross bar of the cage metal above the ball to serve as a back stop for the resilient ball stop. The same protection is provided in the closed type cages, when needed, by optional ball guides having a metal insert in their upper portions.

(This item supplements John N. Martin, Manufacturer data on Pages 3208-3212 of the Composite Catalog, 23rd [1958-59] Revision.)

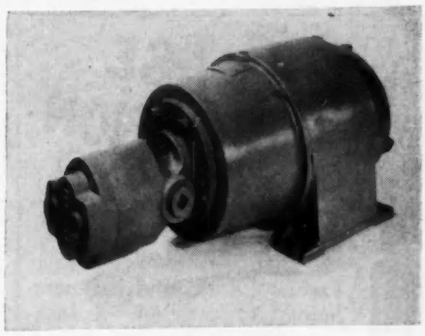
For more data, circle **No. E14** on Readers' Service Card, last page this issue.

PLMV Valve

This new PLMV valve is another exclusive addition to the Parkersburg Rig & Reel Company line of production equipment accessories. Its features include a tee body (combination angle-globe) flip-up weather proof housing for stem and travel indicator, plus carboloy stem and seat to provide maximum protection against erosion. It is available for working pressures up to 6,000 pounds and in 1-inch and 2-inch sizes.

(This supplements Parkersburg Rig & Reel Company data on Pages 4005-4044 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E15** on Readers' Service Card, last page this issue.



New Gas-Electric Pumps

Brown & Sharpe Mfg. Company, Hydraulic division, announced development of two new pumps, an electric and a gasoline engine driven pump for oil field service.

These pumps are especially adapted for pipe line gathering and oil treating operations as well as for machine and hydraulic applications where high volume is required.

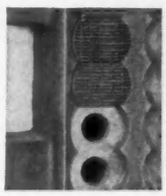
For more data, circle **No. E16** on Readers' Service Card, last page this issue.

VARCO

Type SRL-Long Rotary Slips Provide the–Long Life–Safety–Low Maintenance Costs Needed for the Deepest Drilling!

Type SRS — Short Rotary Slips Available for Shallow to Medium Drilling

VARCO type SRL-Long Rotary Slips are especially designed, carefully manufactured and the most modern controlled heat treatments are employed to produce highest quality performance. They have the greatest amount of line contact per weight and equal size of any Rotary slips. Their advanced design combines light weight with high ultimate strength to provide the greatest possible protection for deep drilling.



FIRM HOUSING OF BUTTONS IN INDIVIDUAL COUNTERBORES integral to the slip body prevents wear and danger of elements falling into the hole.

SHALLOW TOOTH BUTTONS reduce penetration to the minimum. The gripping element renders maximum line contact.

Only VARCO Rotary Slips incorporate all these advanced principles.

1. Shallow tooth gripping element with maximum line contact and minimum penetration. **2.** All gripping elements individually, firmly and safely housed in counterbored slip bodies. **3.** Self-aligning hinge blocks. **4.** Forged and heat treated alloy steel handles. **5.** Maximum strength. **6.** All component parts of VARCO Rotary Slips are made from selected alloy steel and they are subjected to multiple heat treat operations to obtain maximum strength and toughness.

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Composite Catalog, Page 3419

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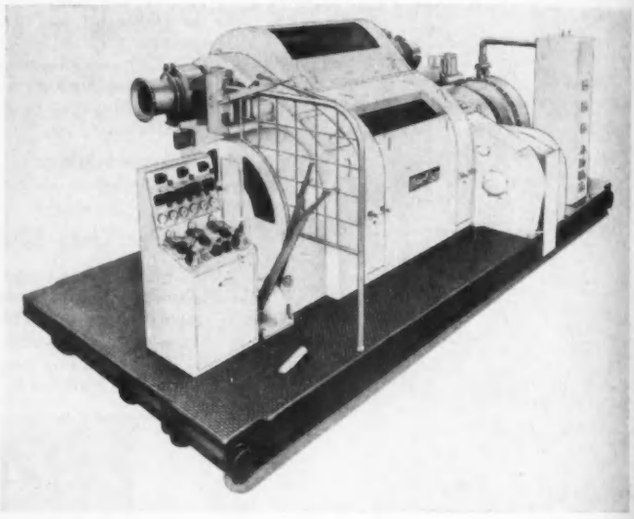
New 760 Drawworks



This 760 drawworks is built for the 7,000 to 12,000-foot drilling range. It is very compact and surprisingly light in weight for a drawworks of its class.

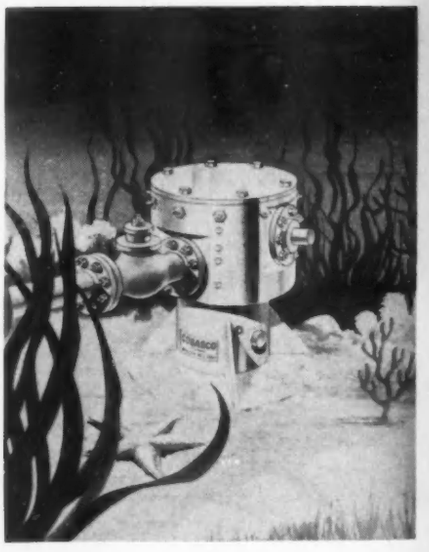
The powerflow scheme is a simple, timeproved design used successfully for a number of years in other "Oilwell" drawworks. Efficient transmission of power has been achieved by careful selection of sprocket sizes and speed ratios combined with effective lubrication.

A highly functional console provides full air control of clutching, shifting and engine throttling. A feature of the control panel is a push-button compounding arrangement. It permits either hand or foot throttle control of engines as required by the driller.

(This item supplements Oil Well Supply Division, United States Steel Corp., data on Pages 3813-3932 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E17** on Readers' Service Card, last page this issue.

Stainless Steel Wellhead



Development of a one-piece unitized wellhead, made entirely of corrosion-resistant stainless steel for offshore drilling applications, has been announced by Cosasco Division of Perfect Circle Corporation.

The new wellhead is designed for installation on the ocean floor or for use in tidelands locations where "splash-area" protection is necessary.

(This item supplements Cosasco Division, Perfect Circle Corp. data on Pages 1465-1468 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E18** on Readers' Service Card, last page this issue.

BROOK TOTALLY ENCLOSED, FAN COOLED, MOTOR DRIVES INCINERATOR DRAFT FAN.

An ideal application for this 30 HP Brook Totally Enclosed, Fan Cooled, Slip Ring Motor—built to resist heat or cold, dust, fumes, moisture. It is driving an induced draft fan handling washed flue gas and raw air at 350°F. in an American Incinerator Corp. system processing municipal waste. Brook A.C. Motors are winning praise in every industry for dependable service and overall economy. They can save for you! Warehouses, Sales Representatives, Dealers throughout the country. Send for literature.

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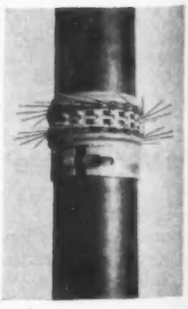
BROOK MOTOR CORPORATION

New Scratcher



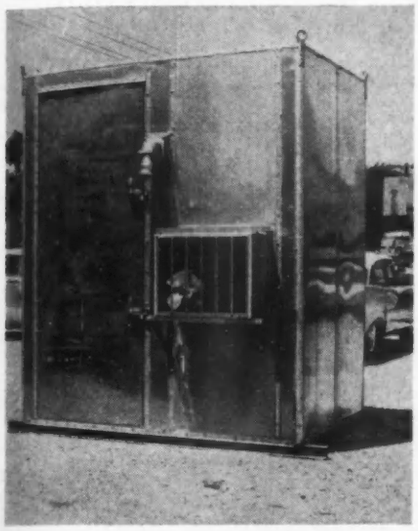
B and W, Inc., has developed a combination Friction Lock Clamp-Solid Nu-Coil Scratcher, a new fixed device for removing mud cake from well walls and assuring proper circulation during cementing operations. This combination unit is slipped over the casing to a selected position and the Friction Lock

Clamp is tightened with a power impact or hex set wrench.

Being a fixed scratcher, rather than a floating or free-moving unit on the pipe, this new unit provides 100 percent effectiveness in removing filter cake from the formation. Every foot that the pipe moves during reciprocation moves the unit one foot. Numerous tests have proved that there is no more deformation of fixed scratchers on removal than with the floating type. It also eliminates welding on casing for holding purposes, which in many cases is injurious to the casing.

(This item supplements B and W, Inc. data on Pages 269-276 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E19** on Readers' Service Card, last page this issue.



Strong Aluminum Buildings

The Lloyd T. Gibbs Company recently announced the construction of strong aluminum buildings which have proved valuable, particularly in recent offshore operations in Louisiana.

Constructed of Lindsay Structure components, all wall sheets are held in tension to give the building extra rigidity and strength. The entire building is bolted together. Should any repairs be necessary, they can easily be made by inexperienced men on the job site.

For more data, circle **No. E20** on Readers' Service Card, last page this issue.

New "Slim Hole" Pump

A new subsurface pump with a 7/8-inch bore is now available for slim hole completions and stripper productions from the Axelson Manufacturing Company, Division of U. S. Industries, Inc.

This new pump is a miniature version of the Axelson SureSeal line—complete with clutch features—plus the added advantage of a Hevi-Well barrel tube. The pump is rated for 6,000-foot maximum depth. Other features of the pump include chrome-plated box end plunger, Axloy balls and seats and top and bottom cup hold-downs. The largest diameter of the pump is 1.260 inches. The drift diameter of the 1¼-inch Non-Upset tubing is 1.286 inches.

(This item supplements Axelson Manufacturing Co. data on Pages 229-264 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E21** on Readers' Service Card, last page this issue.

HYCALOG

HYCALOG V-DOOR BITS PATENT APPLIED FOR SAVE OPERATORS BIG MONEY IN GULF AREA

Some actual cases:

CONTINUING RESEARCH FOR LOWER COST DRILLING

BIT #1408, 6 9/16" O.D.

Averaged 5.7 ft./hr. from 9,700 to TD of 12,350 in Duval County, Texas. Then it was run in a second well in Kenedy County from 10,006 to 10,759 at an average of 3.4 ft./hr. This one bit racked up a total 3,403 feet of hole through sand and shale.

BIT #1457, 6 1/16" O.D.

Averaged 4.1 ft./hr. through 1,328 feet of Miocene in Acadia Parish, Louisiana. Drilling in the first 500 feet was limited by operator to 6 ft./hr. due to hole condition, but the bit could have made 15 ft./hr. And it was good for lots more hole after reaching TD of 14,100.

BIT #1469, 5 23/32" O.D.

Averaged 2.8 ft./hr. from 16,603 to 17,500 in Jeff Davis Parish, Louisiana. Replaced an estimated 25 rock bits for which the trip time alone would have cost about $17,500. Other drilling costs were reduced proportionately because of the time saved.

These are the records of three bits in wells recently completed. And they're typical. We've picked them to show the exceptional economy of drilling with our V-Door bits in the Gulf area.

Your Hycalog representative has a stack of similar outstanding records made in the Gulf and other areas. Ask to see them. But, better yet, try a Hycalog V-Door bit on your next drilling program.

Hycalog, Inc.

505 AERO DRIVE
SHREVEPORT, LOUISIANA

BRANCH OFFICES IN PRINCIPAL OIL PRODUCING AREAS

DIAMOND CORING • DIAMOND BITS • WELL LOGGING • CORE ANALYSIS

AT THE TURN OF THE

Started in 1929, the COMPOSITE CATALOG was a success even in the depths of the depression. From its beginning, COMPOSITE CATALOG's creed has been *service to the industry.*

On that foundation has been built the most useful oil field equipment-service volume ever conceived. It is here to help make your buying and specifying job easier.

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All over the world, wherever oil is sought or produced, there you'll find COMPOSITE CATALOG. Our aim during the next 100 years of oil progress will be to make it even better for you.

COMPOSITE CATALOG OF OIL

Published by WORLD OIL Gulf Publishing

FIRST OIL CENTURY . . .

Composite Catalog

looks back on 30 years of service to the industry.

1929 **One-volume catalog carried 504 pages from equipment-service companies, in first edition.**

1959 **Three-volumes carried 5,384 pages of equipment-service information, in 23rd revision.**

FIELD EQUIPMENT AND SERVICES

Company, P. O. Box 2608 Houston, Texas

CUT STUCK SAND LINES INSIDE TUBING

KINLEY SAND LINE CUTTER

M. M. Kinley Company, Licensees

ABILENE, TEXAS—Hudson-Eads, Inc....OR 2-5331
BAY CITY, TEXAS—J. P. Graham.....CI 5-4526
BEAUMONT, TEXAS
Assoc. Eng. & Eqpt., Inc....TE 5-7046, ZF 8-2023
CASPER, WYOMING—C. A. White.....3-5264
GLENDIVE, MONTANA—C. A. White...EM 5-3833
HOBBS, NEW MEXICO
Horne Well Service Co.....3-5396
HOUMA, LOUISIANA
Assoc. Eng. & Equip. Co.....UP 2-0347
HOUSTON, TEXAS
Assoc. Eng. & Eqpt., Inc.....CA 5-1103
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Davis-Kemp Tool Co., Inc.....5541
LAFAYETTE, LOUISIANA
Assoc. Eng. & Eqt., Inc.....CE 5-6770
LAUREL, MISSISSIPPI
Assoc. Eng. & Equip. Co.....8-7588
LIBERAL, KANSAS
Rainbo Service .....Main 4-3598
LINDSAY, OKLAHOMA
Rainbo Service Co.....PL 6-2530
MIDLAND, TEXAS
Luecous Service & Eqpt. Co.....MU 2-1631
OKLAHOMA CITY, OKLAHOMA
Rainbo Service Co.....ME 4-2131, ME 4-0105
VIDALIA, LOUISIANA
Davis-Kemp Tool Co., Inc.....435
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ELECTRIC HEATING CENTRIFUGE
SIMPLEX TYPE

Patented
Model A-4-12-S

Rotates and heats according to A.S.T.M. specifications

For those preferring a separate Centrifuge and Heater

Heated samples are placed in the trunnion cups where they remain hot during rotation. Of the same design as the combination unit although smaller, lighter and with less wiring. Operates independently of heater, although cups heat while rotating.

Equipped with three stage rheostat switch. Furnished in A-2, (A-2-S), A-4, (A-4-S), and B-2, (B-2-S) models. For use in cars using either 6 or 12 volt batteries. (Specify voltage when ordering)

L-K
Pump Valve Company
P. O. Box 901 Houston, Texas

New Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Readers' Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Packer Retriever Folder

A four page folder describing a Packer Retriever, a new tool which offers safe measure for retrieving drillable production packers, is now available from Bowen ITCO, Inc.

The folder covers the tool's use and advantages, with illustrations of the tool in operation, sectional drawings and complete instructions for release and resetting procedure.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

Technical Data Folder

As an aid to evaluating and planning lease automatic custody transfer installations, Ralph N. Brodie Company has assembled a technical data folder.

The folder includes specially prepared schematic drawings of complete L.A.C.T. metering units, various bulletins describing Brodie positve displacement meters, strainers, automatic control valves, automatic temperature compensator with full range gravity selector, air eliminators and other specialized equipment.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

Selector Slide

Jerguson Gage & Valve Company have announced a new Slide Selector for easy selection of the correct size and type of liquid level gages and valves for any job. The pocket size Selector condenses specifications, sizes and other data in an easy-to-use form.

Other data includes individual Pressure-Temperature graphs on each type of gage, illustrations of various gage-valve combinations and cross-section illustrations and data on various types of valves.

To get a copy, circle **No. E24** on Readers' Service Card, last page this issue.

Dall Flow Tube Bulletin

The precise Dall Flow Tube, which reduces pumping costs by delivering the lowest head loss obtainable with any known velocity-increasing differential producer, is the subject of a new bulletin issued by Builders-Providence, Inc., a Division of B-I-F Industries, Inc. The bulletin contains photographs, dimensional and capacity tables, installations diagrams, a pressure-recovery performance chart and explanatory text.

To get a copy, circle **No. E25** on Readers' Service Card, last page this issue.

Specification Folder

Engineers, buyers and others faced with the problem of determining the proper specifications to apply to the various types of carbon, alloy and stainless steel tubing, pipe, seamless welding fittings and flanges, will be interested in a new four-page folder published by the Tubular Products division of The Babcock & Wilcox Company.

Identified as TDC-186, this folder is a ready cross reference between the type of steel, the application and the specifications covering the product. ASTM specifications and a number of special B&W specifications covering the products mentioned also are included.

To get a copy, circle **No. E26** on Readers' Service Card, last page this issue.

Oil Plunger Bulletin

Dozier Eastman and Company announce that the Oilmaster Oil Lubricated Plunger is described in a new four-page Technical Bulletin EC 5805. The new bulletin covers operational details, general description, specifications and cataloged parts information.

To get a copy, circle **No. E27** on Readers' Service Card, last page this issue.

Drilling Engine Bulletin

The complete product line of drilling engines, diesel-electric drilling rig power plants, and engine-generator sets made for oil field applications by the White Diesel Engine division of the White Motor Company is described in a 20-page bulletin recently issued by the Springfield, Ohio, firm.

Known as Bulletin #106, the catalog summarizes performance characteristics of 26 Superior engine models, offering a range of 200-2150 BHP and 150-1500 KW, naturally aspirated or supercharged, and operating on natural gas, diesel, or dual-fuel.

The literature makes liberal use of action and product photos, cutaway and dimensional drawings, graphs, and specification tables for ready reference. A list of representatives and principal distributors is included on the back cover.

To get a copy, circle **No. E28** on Readers' Service Card, last page this issue.

New Petroleum Catalog

Chiksan Company, Brea, California, subsidiary of Food Machinery and Chemical Corp., has now available a new 24-page catalog for the petroleum industry. Designated "P-8" the catalog incorporates some of Chiksan's newest products, including the 15,000 pound test Longsweep joint for cementing.

To get a copy, circle **No. E29** on Readers' Service Card, last page this issue.